New Scientist

WEEKLY 23 July 2022

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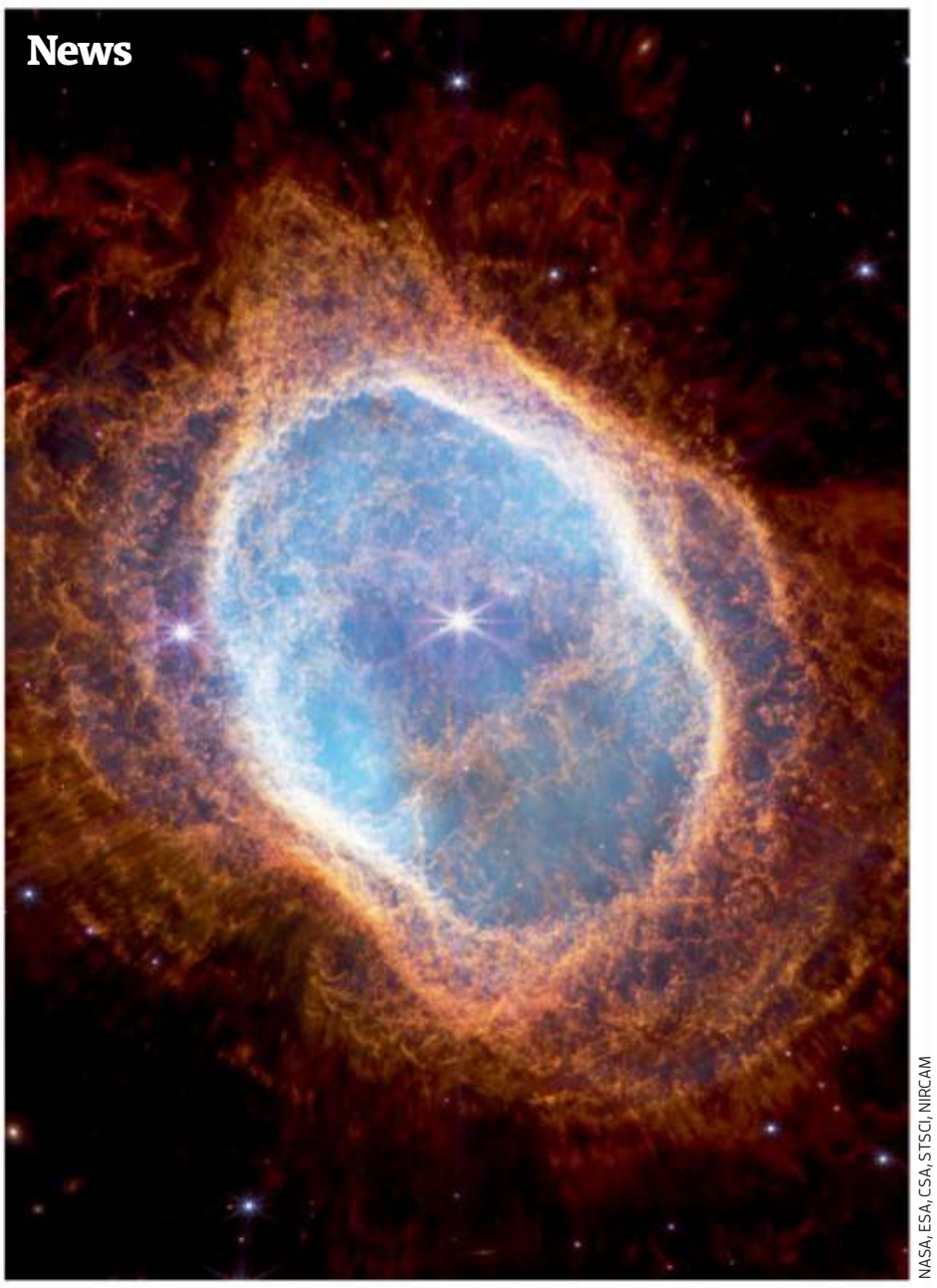

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Science of rewilding: Iberá National Park, Argentina

Explore rewilding in a hugely ambitious conservation project, Iberá National Park in Argentina. Discover one of the world's largest freshwater wetlands and see a vast array of wildlife, including jaguars, giant otters, capybara and a huge variety of birdlife. Plus, stay in luxury lodges and spend time in the cosmopolitan capital of Buenos Aires. From 25 September for eight days. The cost is $10,885.

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Podcast

Weekly

The team explore the promise of using modified pig hearts in humans. They also find out how new space images are helping us peer back into the early universe. Plus, tune in to find out how covid-19 is impacting sperm.

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SHUTTERSTOCK/FOTYSTORY

Argentinian rewilding Visit this ambitious conservation project

MATEUSZ PIESIAK/NATUREPL.COM

Hard knocks Now we know why woodpeckers have a spongy skull

Video

Slow reveal

Slow-motion video of woodpeckers' pecks has upended our understanding of why they have spongy skulls. Rather than absorbing shock from repetitive blows into trees, where they find insects and carve out their nests, woodpecker skulls have evolved to deliver a harder and more efficient hit into wood, much like a well-designed hammer.

youtube.com/newscientist

Newsletter

Fix the Planet

Energy bills in Great Britain are soon expected to hit more than £3200 a year on average. Chief reporter Adam Vaughan explores a trial that incentivised households to time-shift their electricity use during peak times, with the aim of lowering bills and cutting carbon release. He looks at how it could be expanded to the whole of Great Britain.

newscientist.com/fix

Podcast

"They used pig hearts with 10 genetic changes to prevent rejection"

Essential guide

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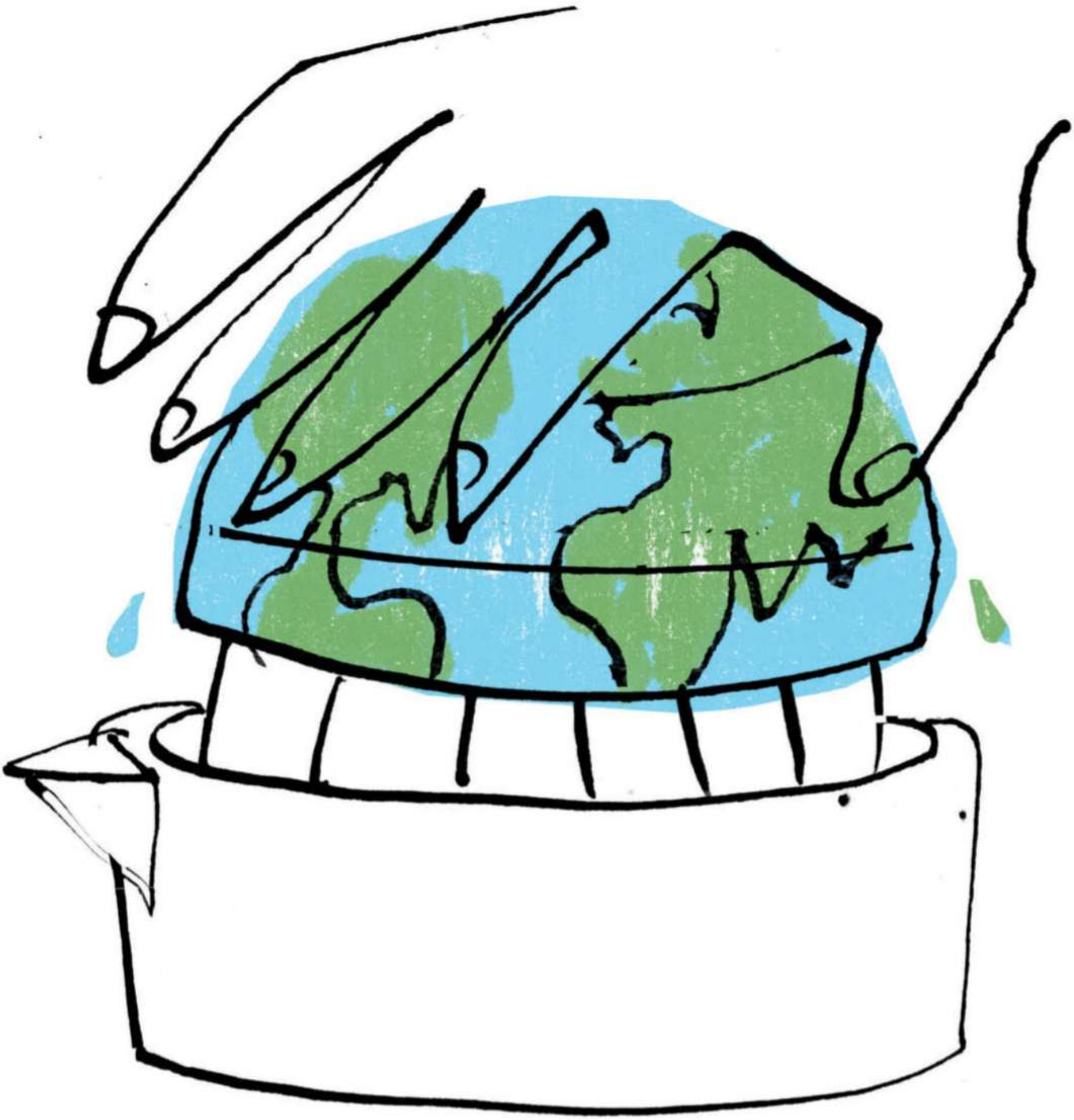

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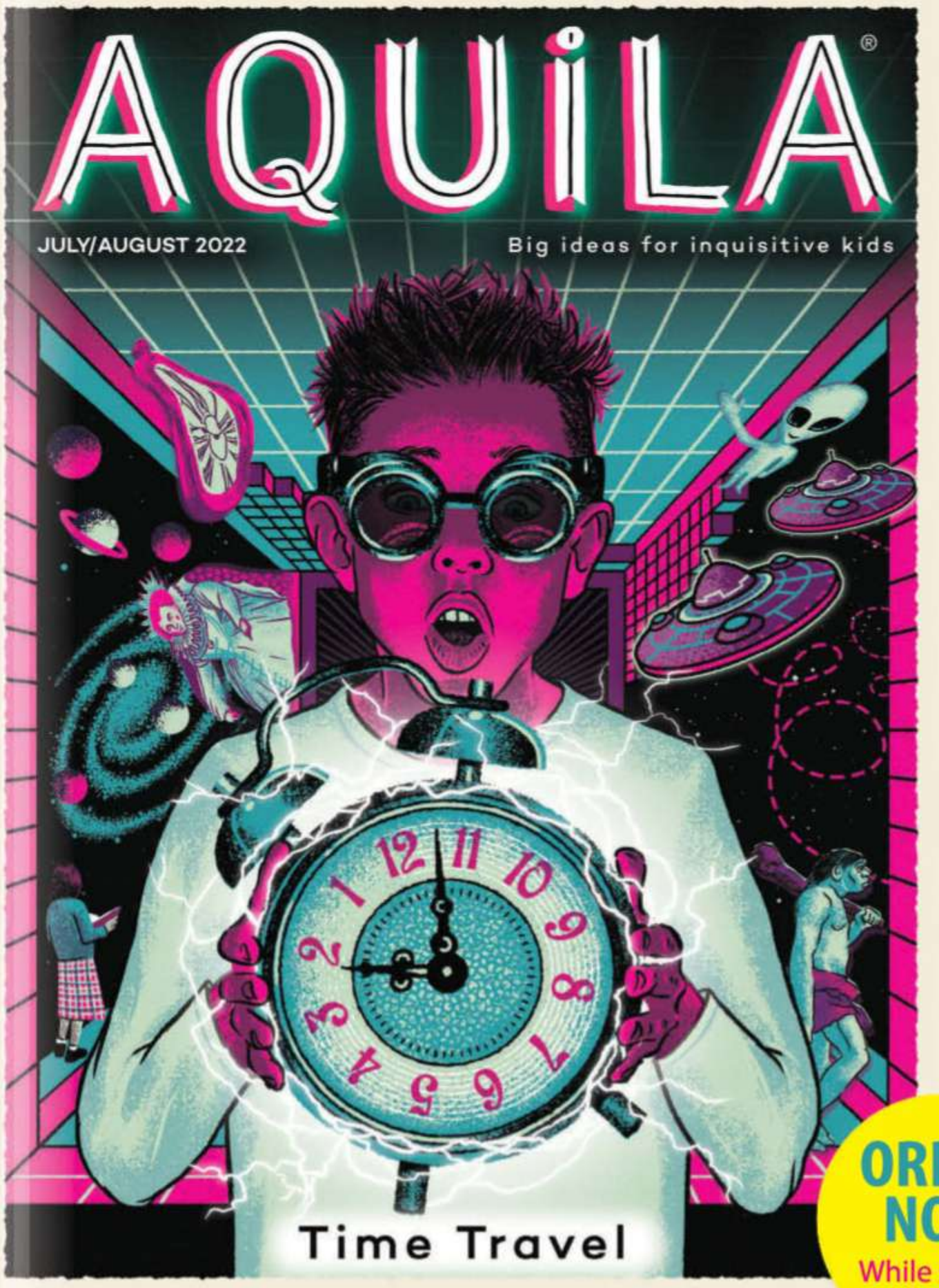

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In this issue: History of Time Machines; Delia Derbyshire's electronic music; Tracking time in space; Mathematical paradoxes; Twisted timelines and a leap into the future. PLUS! Extra Summer – fun activity pages.

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Coming up next...
In September join AQUILA's visit to *Pompeii* the day before the AD79 eruption. Peer into October's *Spooky issue* if you dare, then in November – we step out *On the Stage*...

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Climate change hits hard

Will the European heatwave finally spark politicians into action?

HOW hot do you want it? That's the question facing world leaders this week as heat records were broken, forests burned, economies were disrupted and people died. The lethal heat should act as a wake-up call for politicians about the urgency of acting on carbon emissions, not least leaders in the UK, which provisionally hit a previously unthinkable 40.2°C as *New Scientist* went to press (see page 7).

You might imagine the response would be an emergency political mobilisation like the one triggered by the covid-19 pandemic. Yet there was no breakthrough announcement from 40 countries at the annual Petersberg Climate Dialogue held in Berlin this week. Climate action has barely been mentioned by politicians competing to be the new leader of the Conservative party and next UK prime minister, despite the country hosting the COP26 climate summit just eight months ago. Germany is reactivating coal plants in response to a Russian squeeze on gas. And across the Atlantic, a multibillion-dollar US plan to curb its carbon footprint

"The heat has exposed the UK as being woefully ill-adapted to climate change"

was once again blocked by a single politician, Joe Manchin.

The heat has exposed the UK, one of the richest countries in the world, as being woefully ill-adapted to climate change. Schools closed. Hospitals creaked. Flights were halted. Unfortunately, the UK isn't alone: most adaptation globally has been fragmentary and incremental. This episode should be a reminder of what scientists have already warned: there are limits to adaptation.

All this is happening at 1.1°C above pre-industrial levels. The world is on track for 3.2°C of warming by 2100 at the high end, or 1.9°C of peak warming in the most optimistic analysis. If we allow such global warming to happen, today's heatwaves will seem modest. Much more deadly extremes will become possible.

The glimmer of good news is we can still do something. As science report after science report reminds us, we have the tools to rapidly cut emissions. This week's deadly heat should give political leaders the mandate they need to use them. ▮

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JOSE SARMENTO MATOS/BLOOMBERG VIA GETTY IMAGES

An umbrella wards off the sun in Canary Wharf, London, on 18 July

Climate change

UK hits 40°C for first time

UK temperature record broken as extreme heatwave causes fires, evacuations and deaths across Europe, reports **Adam Vaughan**

THE maximum temperature in the UK exceeded 40°C for the first time ever as *New Scientist* went to press, during a heatwave that hit much of the country, closing schools and disrupting transport. The provisional temperature reported at London Heathrow at 12.50pm on 19 July was 40.2°C, followed by 40.3°C at Coningsby, Lincolnshire.

Heat records normally go up in small increments, but this is 1.5°C more than the record before this heatwave, of 38.7°C from 2019.

Climate scientists say that 40°C would be extremely unlikely in the UK without climate change, and that heatwaves have been made more likely and more intense by global warming.

The UK also recorded its provisional hottest ever overnight temperature between Monday and Tuesday, at 25.8°C in London.

Europe is sweltering in extreme heat, triggering forest fires. Thousands of people have been evacuated and hundreds of deaths have been blamed on the heat.

The deadly heat affecting the continent came as government ministers from more than 40 countries met in Berlin for annual climate change talks known as the Petersberg Climate Dialogue, discussing help for low-income countries and how to cut carbon emissions faster. UN secretary-general António Guterres said countries were failing on climate action. "We have a choice. Collective action or collective suicide," he said in a statement.

In the UK, health authorities encouraged people to stay out of the sun during the hottest part of the day and advised against non-essential travel. Some parents across England told *New Scientist* that their children's schools were closed or closing early on Monday and Tuesday, despite the government saying there is no public health reason for closures.

40.3°C
Temperature at Coningsby, Lincolnshire, on 19 July

Rail services were cancelled or ran slowly. Luton airport halted flights temporarily after part of a runway lifted off in the heat.

Elsewhere in Europe, fires raged across France, Greece, Portugal and Spain. A warning of "very extreme danger" of fire was forecast for many parts of those countries, with "danger" warnings extending as far north as Belgium, the Netherlands and the UK. More than 1000 deaths have been attributed to the heat in Portugal and Spain over the past few days.

"Severe heatwaves are a problem that's not going away, and they will get worse," says Hannah Cloke at the University of Reading, UK. "So we can no longer tolerate poor design of our buildings and our cities. And we urgently need to think about things like reducing overheating, shading trees, building for cooling and providing these public cooling spaces."

Sleep is interrupted for many people during heatwaves, says Laurence Wainwright at the University of Oxford, which could trigger existing mental health conditions.

"That temperatures are as high as they are is because of human-induced climate change. And we are very certain about this now," says Friederike Otto at Imperial College London.

On Monday, the High Court of Justice in London ruled that the UK government's 2021 net-zero strategy had failed to meet its legal obligations by not quantifying in sufficient detail how the plan would meet carbon targets.

"This decision is a breakthrough moment in the fight against climate delay and inaction. It forces the government to put in place climate plans that will actually address the crisis," said Sam Hunter Jones at environmental law group ClientEarth in a statement. ▮

Astronomy

A delightful deluge of stars

The first set of science images from the James Webb Space Telescope is an incredible feast for the eyes, mind and heart

IT HAS been just over a week since we got our first glimpse of the power of the James Webb Space Telescope (JWST), with a sneak peek unveiled by US president Joe Biden on 11 July ahead of a presentation from NASA and its partners on 12 July.

Despite technical hitches – streaming video around the world is somehow more difficult than capturing starlight from across the universe, it seems – astronomers took visible glee in being able to share their new views of the cosmos with everyone else.

"JWST has produced images worthy of the history books in just six months since it launched"

The reaction to these images has almost universally been one of wonder and excitement. They are all the more impressive for how quickly JWST has got to work, producing images worthy of the history books in just six months since its launch in December 2021. In contrast, while the Hubble Space Telescope was launched in 1990, it wasn't until 1995 that NASA released its most iconic picture, the Pillars of Creation, in part due to problems with the telescope that had to be rectified by astronauts.

In this special report, we highlight some of the best pictures released so far, detail the science that astronomers have already teased out of data collected by the telescope (see "A glimpse of chemistry in a distant galaxy", right, and page 13) and answer questions from *New Scientist* readers who have been wowed by the imagery (see page 10).

In a world so often filled with hardship, it is good to have something that we can all look up to. **Jacob Aron**

NASA, ESA, CSA, AND STSCI

One of the brightest nebulae in the sky, the Carina Nebula is a huge cloud of gas and nascent stars. It is about 7600 light years from Earth in the direction of the constellation Carina. The top part of the image is full of huge, hot stars, shining onto the stellar nursery at the bottom of the picture.

"Today, for the first time, we're seeing brand new stars that were completely hidden from our view," said JWST scientist Amber Straughn at the 12 July release of the telescope's first images. "We see examples of bubbles and cavities and jets that are being blown out by these newborn stars. We even see some galaxies sort of lurking in the background up here. We see examples of structures that honestly we don't even know what they are."

The orange ridges in the so-called cosmic cliffs of this image are up to 7 light years high, jutting into a cavity in the nebula. The cavity was carved out by the intense radiation and stellar winds of the young stars at the top of the image, a process that continues to chip away at the gas and dust. The streamers of gas and dust in the centre of the picture are in the process of being heated and blown away from the denser, cooler area below.

As JWST observes in infrared wavelengths instead of visible light, it peers through the cosmic clouds to see young stars that were blocked from previous observations.
Leah Crane

7600
Distance in light years to the Carina Nebula

7
Height of the "cosmic cliffs" of dust and gas in light years

Early universe

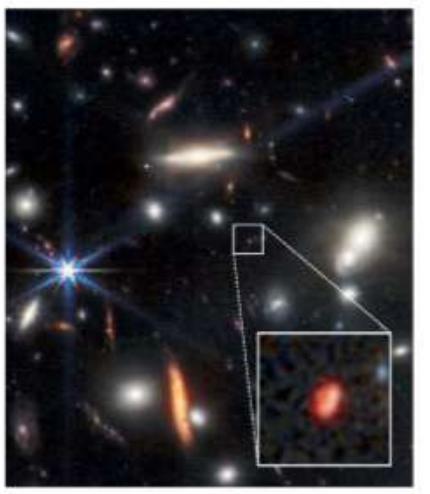
A glimpse of chemistry in a distant galaxy

Will Gater

THE spectrum of light from an inconspicuous red galaxy in JWST's "deep field" image (see page 13) has set astronomers' hearts aflutter. Produced by the telescope's NIRSpec instrument, which uses tiny windows to isolate and analyse the light from objects within the telescope's field of view, it is an unprecedented insight into a galaxy present in the early universe.

Such had been the secrecy around the capture and release of the first JWST observations that some of the NIRSpec team weren't even aware of the existence of the spectrum until the public announcement on 12 July. But there was one feature of the data that NIRSpec team member Andrew Bunker, at the University of Oxford, saw was "a real step [forward] within minutes of the data being released".

Among the various hallmarks of different elements within the galaxy was a particular fingerprint – what astronomers call an emission line – of glowing oxygen gas, with a wavelength of 436.3 nanometres. The NIRSpec team had hoped to observe this



NASA, ESA, CSA, AND STSCI

The distant red galaxy occupies just a handful of pixels in JWST's image

emission line in extremely distant galaxies, says Bunker, but anticipated having to search "dozens or hundreds" of targets to uncover it. "I don't think we really dreamt that within the first, essentially publicity, snap that it would be there. That's really quite incredible," he says. It is all so sudden that the galaxy doesn't even appear to have a name.

The oxygen line is important because astronomers use it to calibrate their measurements of the compositions of galaxies. If you can see this line with your instruments, and are able to compare it with other oxygen emission lines in a galaxy's light, you unlock a way to translate the apparent prominence of different chemical fingerprints in a spectrum into how much of those chemicals are really in the galaxy. Scientists have done this for nearby galaxies before, says Bunker, but not for far-off ones.

Future JWST spectra will allow researchers to explore how the proportion of elements heavier than helium in distant galaxies has changed over time. "It gives you data points on that evolution," says Emma Chapman, an astrophysicist at the University of Nottingham, UK.

Insights like these have the potential to revolutionise what we know about the early universe. "There is a missing billion years in our understanding of the evolution of our universe," says Chapman. "From around 380,000 years after the big bang to about a billion years after, we have very little information. Now, JWST is being able to dive right back into that era." ▮

Space exploration

Collision risk may limit Webb's view

SCIENTISTS may have to avoid pointing the James Webb Space Telescope (JWST) in certain directions too often for fear of damage from space rocks.

During the six-month period of instrument testing called commissioning, JWST was struck by at least six micrometeoroids, pieces of space dust that orbit the sun. Space is full of these tiny rocks, and the team expected a single collision per month, but one that struck a segment of the telescope's mirror in May was larger than anything anyone predicted before its launch.

According to a report on JWST commissioning released on 12 July, that strike "caused significant uncorrectable change in the overall figure of that segment. However, the effect was small at the full telescope level." Thanks to the precise control mechanism needed to align the 18 segments of the mirror, engineers were able to tweak their positions to mostly mitigate the effects of the micrometeoroid strike (arxiv.org/abs/2207.05632).

Nevertheless, too many of these strikes could seriously degrade the segments. The JWST team is now working on new models to figure out how common events like this should be and how to deal with any damage they might cause. That might even mean avoiding pointing the telescope in the direction in which it is travelling to stave off head-on collisions. ▮ **LC**

Q&A

Cosmic questions answered

New Scientist space reporter **Leah Crane** explains what the first images from the James Webb Space Telescope can tell us and what it will look for in the future

ON 12 July, the first set of full-resolution science images from the James Webb Space Telescope (JWST) was released. This set included astonishingly sharp pictures of the Carina Nebula (see page 8); the Eight-Burst Nebula, also known as the Southern Ring Nebula (below); a group of galaxies called Stephan's Quintet (far right); and a deep-field image showing a galaxy cluster called SMACS 0723 (see page 13) stretching the light of the objects behind it. There was also an analysis of the composition of an exoplanet named WASP-96b.

These images are the culmination of decades of work by scientists and engineers – and they are just the beginning of JWST's exploration of the universe. They have also inspired dozens of questions from *New Scientist* readers, from queries about the telescope itself to what it might be able to do next. Here is a round-up of our favourite questions, along with their answers.

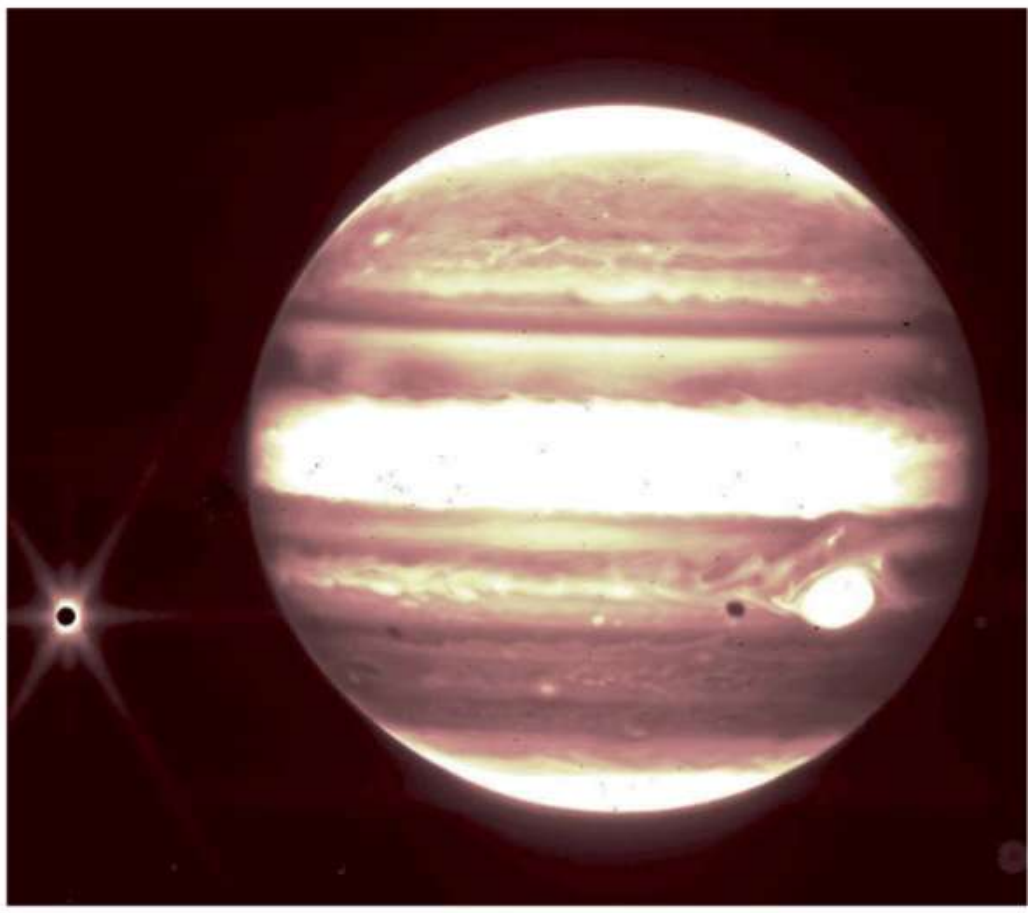
What is so special about these images? Didn't we have the Hubble Space Telescope before the James Webb Space Telescope?
We did and do have Hubble, which delivers so many gorgeous images of space. But JWST is much bigger, so its pictures are more detailed.

It also observes in different wavelengths than Hubble, which allows it to see things – particularly extremely distant things – that Hubble can't.

How close to the edge of the observable universe will JWST be able to see? Official releases have said the telescope can see 13.5 billion years back in time – that seems very close to the age of the universe at about 13.8 billion years.
JWST should be able to see back to between 100 million and 250 million years after the big bang. But while that is up to about 13.5 billion years ago, it isn't 13.5 billion light years away – it is much further than that, because the expansion of the universe has stretched space as light travelled to us, causing it to cross much longer distances.

13.5bn
Age in years of the oldest light the James Webb Space Telescope can see

Will the James Webb Space Telescope study supermassive black holes? Can it produce an image similar to the one from the Event Horizon Telescope?
JWST can't make an image of a supermassive black hole like the Event Horizon Telescope did – that's a different kind of telescope – but it will study them. In fact, the picture of Stephan's Quintet (far right), a galaxy cluster nearly 300 million light years from Earth, is providing insight on one already.



NASA, ESA, CSA, AND B. HOLLER AND J. STANSBERRY (STSCI)

Is it possible for gravitational lensing, like that seen in JWST's first deep-field image, to be strong enough to see yourself? As in light does a U-turn?
Yes! Black holes can have a feature called a photon sphere, where gravity's pull is so strong that light orbits the black hole. So if you aim a light just outside the photon sphere, you could, in theory, see that light come around the other side of the black hole. Depending on the distance to the black hole, it could take a really long time, though – the most laborious selfie ever.

If the James Webb Space Telescope can see 13.5 billion years back, could we one day make a telescope that can "see" further than the beginning of time?
I wish! Unfortunately, there is a fundamental limit to how far back we can see, because up until a little less than 380,000 years after the big bang, the universe was completely filled with hot plasma and was therefore opaque.

NASA, ESA, CSA, AND STSCI

This cloud of dust and gas surrounding two stars is called the Southern Ring Nebula, or the Eight-Burst Nebula, imaged here in infrared.

The nebula is about 2000 light years from Earth and nearly half a light year across. The bright cloud that makes up the ring came from the outer layers of one of the stars at the centre of the nebula, which expanded when it reached the end of its lifetime and transformed from a sun-like star into a white dwarf star.

Two images of this nebula were released among the first JWST images, which revealed the two stars in extraordinary detail. They show that the dimmer, redder star – the one that spawned this nebula – is surrounded by dust, whereas the brighter star may one day puff out its own nebula.

This picture of Jupiter was taken using JWST's near infrared camera, NIRCam, with two different filters to focus on separate wavelengths of light. Jupiter's moon Europa is also visible, as is its shadow just to the left of the planet's Great Red Spot.

The image was taken as part of a test of JWST's scientific instruments to check that the observatory could track objects moving at high speeds through the solar system. Jupiter was the slowest and largest of nine moving targets used for these tests, and it showed that smaller objects like Europa can be tracked even with a bright planet bouncing light into the cameras.

Even if it weren't opaque, though, space and time began simultaneously, so, while this can be hard to wrap your brain around, there is no such thing as "further than the beginning of time". As far as physicists know, there is nothing to see before the big bang.

"These images are the culmination of decades of work by scientists and engineers"

Can we see further back than 380,000 years after the big bang with gravitational waves detected by the Laser Interferometer Gravitational-Wave Observatory (LIGO) or the Laser Interferometer Space Antenna (LISA)?
Unfortunately, the answer is no, because gravitational waves come from the motion of masses and there just weren't any structures big enough to create measurable gravitational waves until about 100 million years after the big bang.

The only way we can see that far back in time is by using the cosmic microwave background, which consists of light left over from the extremely early universe, now spread throughout the cosmos.

With the data and imagery collected, is it possible (or even probable) that scientists will revise the currently accepted age of the universe to be much much older than a mere 13.7 billion years?
It is possible that the data from JWST will cause us to revise the age of the universe based on new measurements of its expansion, but, if so, it will probably go down rather than up. This is because there are two estimates of the rate of expansion of the universe, one of which gives us an age of about 13.8 billion years and the other of which gives an age of about 11.4 billion years.

Was there anything unexpected about the spectra of the galaxy and exoplanet obtained so far?
There wasn't anything particularly shocking in the data that has come down so far, aside from the better-than-expected performance of the telescope itself. The images are all of systems that are already very well studied, but we just have far more detail now than ever before. So, we are seeing new things, but I don't think those are very unexpected.

Why did the JWST crew choose WASP-96b as the first exoplanet to analyse the composition of? What was special about it?
What's special about WASP-96b is that it isn't cloudy – the new spectrum shows some evidence of clouds and haze, but not much. That is good because it allows the light from its star to shine right through the planet's atmosphere and for us to analyse it without being blocked by lots of clouds, which would make these observations more challenging.

How will astronomers decide what to take a picture of with JWST next?
The first year of science has actually already been planned out. Researchers made more than 1000 proposals for what to observe and the best options were selected by panels of scientists who get the final say on where to point JWST. The winning proposals include many more exoplanet observations, views of supermassive black holes smashing together, searches for the first stars and galaxies, and analyses of the large-scale structure of the entire universe.

Why is space so pretty?
The fun answer: because it is everything! The physicist's answer: hydrogen. The actual answer: often it is because we assign colours to dust and gas in order to make our space pictures prettier and more informative. ▮

NASA, ESA, CSA, AND STSCI

These five galaxies, called Stephan's Quintet, are about 290 million light years from Earth in the direction of the constellation Pegasus.

The four at the top of this image are engaged in a deadly game of chicken, swooping past one another closer and closer until, someday in the distant cosmic future, they will probably smash together and merge. We have seen them before – in fact, the group of four is the most thoroughly studied compact group of galaxies – but this image is far more detailed than any of the previous ones. It is a mosaic of almost 1000 pictures, making it JWST's biggest image to date.

That detail allows us to see the area around a supermassive black hole, the brightest part of the top galaxy. "We cannot see the black hole itself, but we see the material sort of swirling around and being swallowed by this cosmic monster," said JWST researcher Giovanna Giardino during a 12 July press conference. This area is 40 billion times as bright as our sun, she said.

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Gravitational lensing

Unscrambling the cosmos

Astronomers are already using the images from the James Webb Space Telescope to reveal a new understanding of the objects they depict, says **Leah Crane**

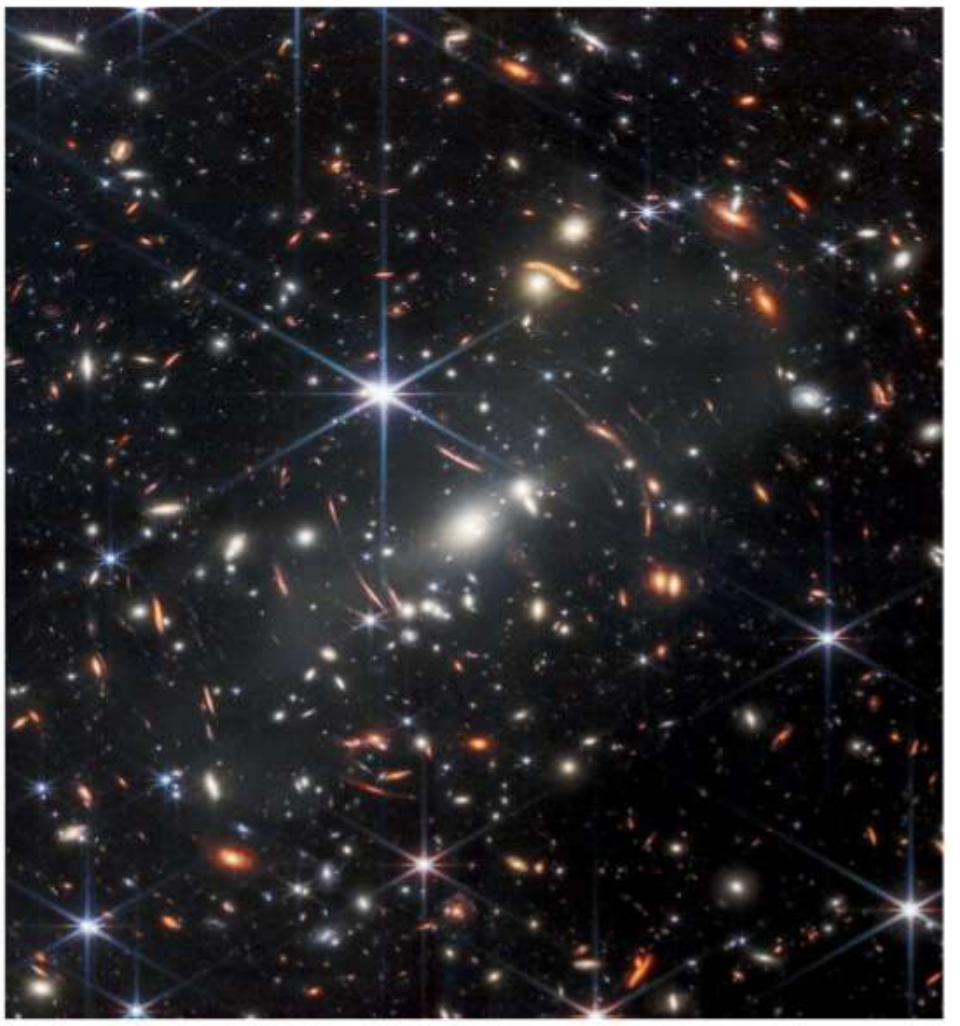
JUST days after the first full-resolution image from the James Webb Space Telescope (JWST) was released on 11 July, two groups of researchers have already analysed the data to recreate the structure of the cluster of galaxies in the image.

The cluster, called SMACS 0723, is so massive that it warps space-time, bending and magnifying the light from the galaxies behind it in a process called gravitational lensing. JWST's image of it is the deepest picture of the cosmos ever created.

"I've been preparing for this since 2005, when I started working on JWST, and when the image came out, it's like I had been going through life without any glasses on and I finally got my first pair of prescription glasses," says Brenda Frye at the University of Arizona. The day the deep-field picture was released, she assembled a team across as many time zones as possible so they could analyse the data around the clock, and then got to work.

A similar tale was unfolding in the UK, where Guillaume Mahler at Durham University and his colleagues began to examine the same observations. "I expected to see galaxies that we'd never seen, so I was ready for new discoveries, but what I was amazed by was how many there were," says Mahler. "At first, it was a bit overwhelming, like: what do we do with all of this?"

The teams began by searching for background galaxies that appeared to repeat, being cloned by the effects of gravitational lensing. This is a common effect of the phenomenon. Mahler's team found 16 repeated galaxies (arxiv.org/abs/2207.07101) and Frye's team found 13 (arxiv.org/abs/2207.07102). Both teams used them to reconstruct SMACS 0723 and calculate where dark matter is lurking within the cluster.



NASA, ESA, CSA, AND STSCI

The first image released by the James Webb Space Telescope team

"What we're seeing, which is so spectacular, is this rich tapestry with so many colours and textures. But what you see is the tip of the iceberg," says Frye. "Every single blob that you see is a galaxy with 10 billion stars, but most of the cluster's mass we can't see because it's invisible dark matter, just like most of an iceberg is underwater."

The researchers found that the cluster is more elongated than we had realised from previous observations with other telescopes. This oblong shape is most likely due to mergers with other large galaxy clusters.

"All of this faint, diffuse light emission from the cluster that we see, this is completely new and unexpected," says Mahler. "It's telling us something about the history of the cluster – all those stars come from destroyed galaxies." As SMACS 0723 devoured other galaxy clusters, it ripped them apart, leaving stars and other matter strewn in a bright streak across the cluster's centre.

Frye's team also spotted an unexpected gap in that faint light. If the cluster finished destroying all those other galaxies a long time ago, we would expect the light to be smoothly distributed, but this strange void indicates that a huge merger may still be going on, says Frye.

One next step among many is to take a closer look at the background galaxies themselves. JWST's resolution is so high that researchers can not only tell which ones are repeated images, but they can also spot bursts of star formation – and maybe even individual stars – in galaxies halfway across the universe.

> **"It's like I had been going through life without any glasses on and I finally got my first pair"**

10bn

Number of stars in every galaxy seen in this JWST image

Anything but boring

SMACS 0723 has been thoroughly studied for years using other telescopes. "For the first release, they tried to find a boring cluster... but JWST is so good that it turned this 'boring' cluster with nothing to learn into this amazing treasure," says Mahler. "We are really seeing galaxies and star formation at the dawn of the universe."

Frye also leads a group that will use JWST to look at seven more galaxy clusters and their gravitationally lensed background galaxies over the course of the next month. Hers is one of several programmes designed to take incredibly deep images of the cosmos, so the coming months are sure to provide a surge of new insights on the earliest stars and galaxies, and the dark matter that sits between them and us. ▮

Field notes Rewilding in Kent

Wild bison roam in the UK for the first time

Four bison were released into an English woodland that they are expected to transform, reports **Adam Vaughan**

MONDAY 18 July was a special day for Tom Gibbs, one of the UK's first two bison rangers. On that day, four bison were released in woodland near Canterbury, south-east England, marking the first time the huge herbivores have been introduced to the wild in the UK. The event is a major milestone for proponents of rewilding UK landscapes, where wildlife and plant declines aren't slowing.

"The job just captured my imagination," says Gibbs, when I visit the site ahead of the release. "This is exactly the form of [habitat] management we need in this country. And it's such a charismatic animal."

The release of two calves from Ireland, a bull from Germany and a matriarch that was being held in captivity in Scotland was delayed by three months due to paperwork headaches around wild animal imports, as the UK is no longer a member of the European Union.

Now the animals are finally in their 205-hectare site, part of a block of ancient woodland called West Blean and Thornden Woods, they are expected to transform it. Today, much of the landscape is dominated by pine trees from conifer plantations that were grown in the 1970s, as well as fern-rich ground cover. "It's a monoculture. Nothing much is growing here, and you've got a handful of species," says Kora Kunzmann at Kent Wildlife Trust, the non-profit group leading the bison project.

As Europe's largest land mammal, the European bison (*Bison bonasus*) is considered an "ecosystem engineer". The animals are heavy enough to break up soil to allow vegetation to grow, and they like eating bark, which will eventually kill trees and create standing deadwood, an important habitat for invertebrates. The bison's habit of rolling around on the ground for a "dust bath" helps burrowing insects too. More insects should in turn attract more birds, including lesser spotted woodpeckers and nightingales, and boost biodiversity.

ROBERT CANIS

The bison were released in woodland in Kent, UK, on 18 July

Eventually, the bison's actions should help transform the habitat into one dominated by silver birch trees, downy birch trees and heather. Gibbs says the bison will be a "game changer" for habitat management. The shifts will occur more slowly than they would with "intensive" management of the land using machinery such as chainsaws, but he says that is to be expected.

4

bison are now living wild in a forest in south-east England

Kunzmann has more than 140 monitoring points to establish a baseline of the species in the area. She will also spend the next five years recording metrics such as how much carbon the soil stores, which will help her measure the effects the bison have on the environment. Their impact will be compared with an empty "control" area, as well as with regions stocked with long-horned cattle.

The project's backers hope the small bison herd will breed, with the first calves potentially appearing within two years, depending on how they settle. The woods are estimated to have enough food to support about 10 animals.

Carefully handling any expansion will be vital, because the species' genetic diversity is very fragile. The bison was wiped out in the wild across Europe in 1927 and was only saved by a breeding programme from 54 animals left in zoos.

Successful releases across Europe mean there are now about 6200 bison in the wild. In 2021, the species was officially declared no longer "vulnerable". Gibbs's main goal will be to avoid inbreeding, meaning bulls may be moved to other sites when they reach sexual maturity.

The bison project faces other challenges. A practical one is the network of metal fences that has been erected in the woods to keep people and the bison separate, along with a series of bison tunnels under footpaths that are a public right of way. Though the woods are private land that is largely owned by the Kent Wildlife Trust, local people have informally become used to being able to walk their dogs off the main paths and in the woods. This is no longer possible.

"My mum doesn't like it because they're cutting off the footpaths so we can't walk through there any more. She doesn't mind the actual bison," says 17-year-old Ella Kimble from nearby Herne. Kimble welcomes the release, a view echoed by her friend, 17-year-old Freya Mcmillan from Blean. "I think it's cool," she says. "They're good for the ecosystem."

Whether the release counts as a return or an introduction is a matter of academic debate. There is no conclusive archaeological evidence that *B. bonasus* ever lived in the UK. But one thing does seem likely – if the bison release is a success, the animals will spread across the country.

"We're hoping this is going to be a trial run for projects like this to happen all over the UK, for people to see that, actually, things like bison can be the nature-based solution that we need in order to restore woodland like this," says Kunzmann. ▮

Human evolution

Skull helps piece together puzzle of ancient human migration into America

Carissa Wong

MATERIAL recovered from a 14,000-year-old skull found in south-west China reveals that the individual was a member of our species, *Homo sapiens*, and had genetic ties to the east Asian ancestors of Native Americans.

The cranium, which belonged to an individual known as Mengzi Ren, was unearthed in 1989 in Red Deer cave in Yunnan province. It has an unusual mix of modern and ancient features, which has led to suggestions that it might represent an ancient human species – despite the fact that it dates to a time when our species is thought to have been the only type of human present on Earth. Others have suggested the cranium might have belonged to an individual of mixed ancient and modern ancestry.

But now, Bing Su at the Kunming Institute of Zoology at the Chinese Academy of Sciences and his colleagues have analysed ancient DNA from the skull and established that Mengzi Ren was actually a female *H. sapiens*. The team sequenced a fraction of the total genome, just 100 million DNA bases, but this was enough to work out the individual's species-level identity.

"It was a really exciting moment," says Su. "It is difficult to find ancient DNA in such a sample. After three years of trying to extract DNA from around 100 spots on the cranium, we found ancient DNA that we could sequence."

By then comparing the genome of Mengzi Ren with ancient genomes from around the world, the team revealed genetic similarities between this individual and living people of east Asian ancestry, as well as Native American people. This suggests Mengzi Ren was related to ancient populations in east Asia that contributed to Native American ancestry (*Current Biology*, doi.org/gqhgk5).

Red Deer cave in Yunnan, China, and the skull found there

XUEPING JI

The east Asian ancestry of Native Americans has previously been inferred by analysing the DNA of living people.

"This is the first time we have sequenced an ancient east Asian genome from the time when people were migrating into America, helping to confirm the east Asian ancestry of Native Americans," says Su.

Based on this genetic analysis, the researchers speculate that some of these ancestors of Native American people may have travelled north along the coastline of present-day eastern China, as well as through the Japanese islands, before crossing into North America from Siberia.

"This work is very exciting, as it shows how the settlement of east Asia is linked to the peopling of America," says Tábita Hünemeier at the Institute of Evolutionary Biology in Spain.

She adds that there is also evidence that some members of the founding population that entered the Americas dispersed westwards back into east Asia. "This could be [another] explanation for the presence of a relationship between Mengzi Ren's ancestry and ancient Native Americans," she says. ▮

Optics

New kind of laser could produce ultra-sharp displays

A NEW kind of laser uses tiny moving particles to create beams of light. The laser is more programmable than standard lasers and the approach could be used to create visual displays that are sharp from all angles.

Conventional lasers repeatedly bounce light between two mirrors until it becomes bright and focused. Riccardo Sapienza at Imperial College London and his colleagues have built a laser that uses particles that can arrange themselves to carry out a similar process.

The new type of laser first requires the use of green light from a traditional laser. The researchers shine this green light into a small glass box filled with a liquid solution containing titanium oxide and silicon oxide particles. This warms up the silicon oxide particles and causes the titanium oxide particles to clump around them.

The green light then bounces between particles in the clump – similarly to how light bounces between mirrors in conventional lasers – until the clump itself starts to emit a laser beam, now in the colour red (*Nature Physics*, doi.org/h479).

By nudging the particles into different positions with the green light, the team can then program the properties of the light emitted by the laser, such as where in the device it originates from and how pure its colour is. By comparison, conventional lasers can't be adjusted after manufacturing.

"Light bounces between particles in the clump until the clump itself starts to emit a laser beam"

Diederik Wiersma at the University of Florence in Italy says that the new laser is the first kind to be programmed by moving its components, which allows it to have multiple functions.

Sapienza says one use for the laser may be in display screens, such as digital billboards.

Particles could move and assemble at a specific location within the display and emit a colour that could be very pure, and visible in both very bright and very dim light and from all lines of sight. ▮

Karmela Padavic-Callaghan

Coronavirus

Impact of covid-19 on sperm

As the pandemic has continued, evidence has built up about the way the coronavirus affects sperm cells and fertility, reports **Carissa Wong**

COVID-19 infections can lower sperm count and the virus may even bind to receptors on the surface of sperm cells. However, there is no evidence to suggest that the effects differ from those seen after other illnesses that involve fever, such as the flu.

Krishna Chaitanya Mantravadi at Oasis Fertility, a fertility clinic in India, tracked sperm counts in 20 men aged 25 to 35 from before they had a SARS-CoV-2 infection to nearly five months after they had fully recovered – that is, were testing negative and had no symptoms. The researchers didn't explicitly look at sperm in trans women or non-binary people – this was the case for all the studies mentioned in this article.

The men visited the clinic before the pandemic after trying to conceive for at least a year. Of the 20 men, six saw no decline in sperm count around 10 weeks after recovering from covid-19, while the other 14 had an average 49 per cent decline.

The team measured the sperm counts of these 14 men again around 11 weeks later and found that levels had recovered somewhat for 11 of them, to an average of 12 per cent lower than prior to infection. The other three men's sperm levels didn't recover at all in this time period. Chaitanya Mantravadi presented the findings at the European Society of Human Reproduction and Embryology conference in Milan, Italy, earlier this month.

"For some men, we just do not know if the effect on semen parameters is permanent," Scott Nelson, an NHS consultant based at the University of Glasgow, UK, said during a separate presentation at the conference, adding that more data on how sperm impairments caused by covid-19 can affect conception is needed. "If you've got a sperm count of, say, 120 million, the chances are that even if they take a hit, you still would have a count of 60 million and you're still probably going to be able to conceive naturally," said Nelson.

This isn't the first study to suggest that infection with the SARS-CoV-2 virus may lead to a temporary drop in sperm count.

"Men with moderate to severe disease may suffer a temporary reduction in semen quality"

A 2021 study led by Gilbert Donders at University Hospital Antwerp in Belgium analysed semen samples from 67 men with an average age of 34 after they had tested positive for covid-19.

The researchers analysed the samples of 35 of these men within a month after they had a positive PCR test, and found a below average sperm count – defined as less than 15 million sperm cells per millilitre of semen – in 13 of them. The team analysed the samples of the other 32 participants at about two months after a positive test, and found just two participants had a below average sperm count, suggesting sperm counts recover over time. This study didn't assess sperm counts in the participants prior to having covid-19.

Amira Sallem at the University of Monastir in Tunisia and her colleagues also presented evidence of covid-19's effects on sperm motility at the conference. They collected two semen samples, one before and another during the pandemic, from 90 people with an average age of 38, and found an average 5 per cent reduction in the proportion of sperm that could swim. However, this study didn't test whether participants had covid-19.

Covid-19 may affect sperm by damaging the tissues that support their development. Lab studies have shown that the SARS-CoV-2 virus can infect cells in the testes and the epididymis, the tube where sperm cells mature. These both carry the ACE2 receptor that the virus uses to gain entry to cells. An imaging study conducted in 26 men during a mild covid-19 infection found that 11 appeared to have an inflamed epididymis.

There is also evidence that SARS-CoV-2 may be able to directly bind to sperm cells. In a study presented at the conference by Chiara Castellini at the University of L'Aquila in Italy and her colleagues, the team found that ACE2 receptors were present on the surface of sperm cells from 40 sperm donors. However, the virus hasn't yet been found inside sperm cells.

Sperm donations

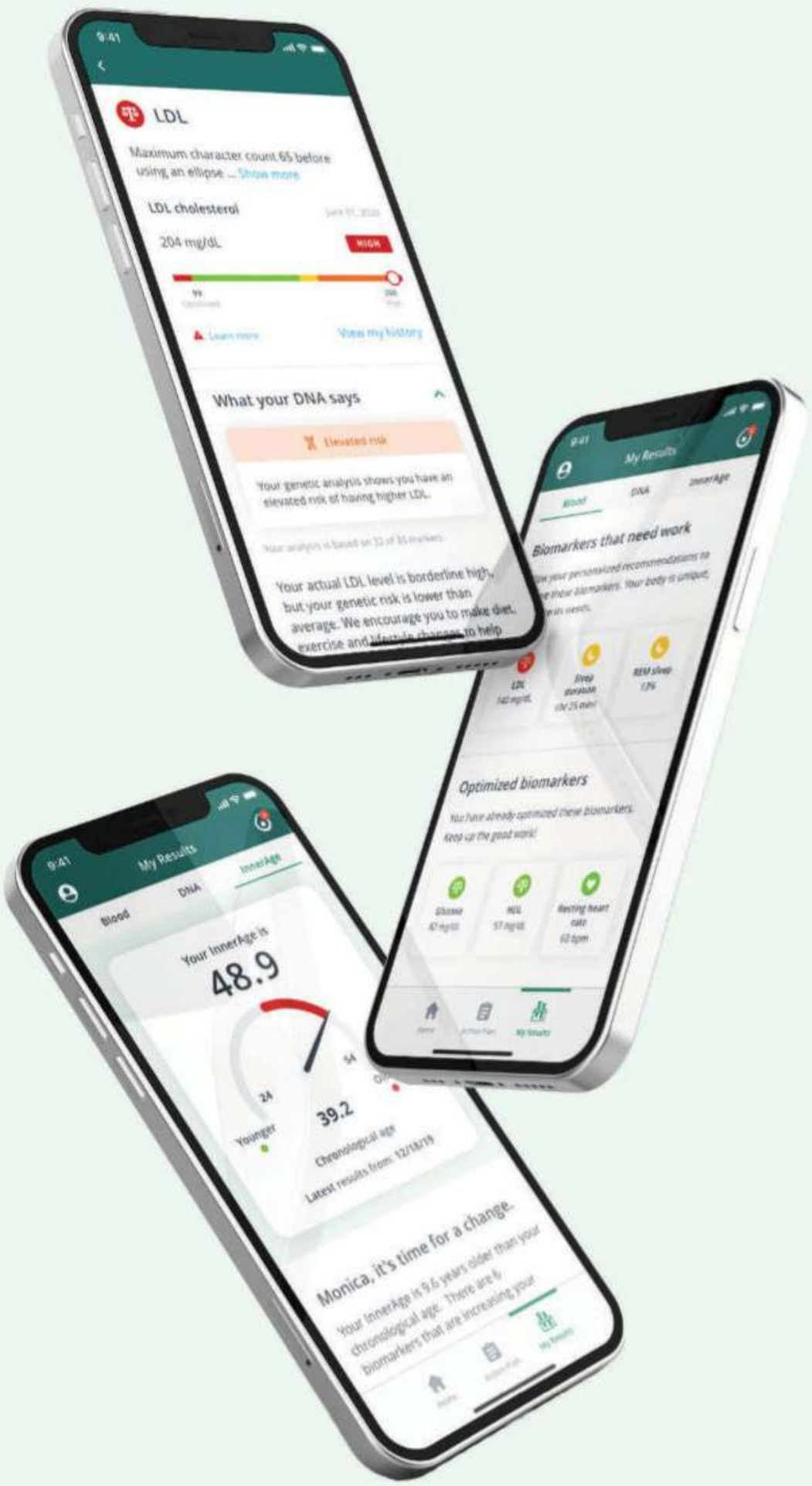
SARS-CoV-2 has also rarely been found in the seminal fluid that carries sperm. Pedro Jose Fernández-Colom at the La Fe University and Polytechnic Hospital in Spain and his colleagues presented work at the conference in which they analysed sperm donated by 50 men between July 2020 and March 2021. They found SARS-CoV-2 in one semen sample. Fernández-Colom told *New Scientist* that the presence of the virus in semen was rare but not impossible. There is no evidence it can be transmitted sexually through semen, he says.

Overall, the effects of covid-19 on sperm are similar to those seen after other illnesses that involve a fever, such as the flu, because sperm are highly sensitive to temperature changes.

"The data suggests that men with moderate to severe disease may suffer a temporary reduction in semen quality, in the same way that is seen with other illnesses [that cause fever]," says Allan Pacey at the University of Sheffield, UK. "As such, I am no longer concerned about any long-term effects for male fertility of a covid-19 infection and see this as no more serious than what we see following an infection of influenza." ▮

A light micrograph of human sperm cells

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY



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Technology

Robot claimed to be self-aware

A machine knows its own position in space, but is this really a form of self-perception?

Chris Stokel-Walker

A ROBOT can create a "mental" model of itself to plan how to move and reach a goal – an ability that its developers say makes it self-aware, though others disagree.

Every robot is trained in some way to do a task, often in a simulation. By seeing what to do, robots can then mimic the task. But they do so unthinkingly, perhaps relying on sensors to try to reduce collision risks, rather than having any understanding of why they are performing the task or a true awareness of where they are within physical space. It means they will often make mistakes – bashing their arm into an obstacle, for instance – that humans wouldn't because they do have physical self-awareness and would compensate for changes.

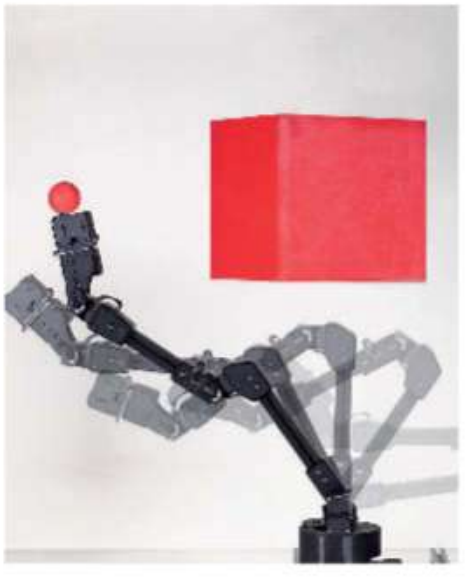
"It's a very essential capability of humans that we normally take for granted," says Boyuan Chen at Duke University, North Carolina.

"I've been working for quite a while on trying to get machines to understand what they are by thinking about themselves," says Hod Lipson at Columbia University, New York, another team member.

Chen, Lipson and their colleagues tried to do that by placing a robot arm in a laboratory where it was surrounded by four cameras at ground level and one camera above it. These fed video images back to a deep neural network, a form of AI, connected to the robot that monitored its movement within the space.

For 3 hours, the robot wriggled randomly and the neural network

Has this robot arm developed a form of "bodily" self-awareness?



CHEN, LIPSON, NISSEL SON, QIN/COLUMBIA ENGINEERING

was fed information about the arm's mechanical inputs and watched how it responded by seeing where it moved to in the space. This generated nearly 8000 data points – and the team generated an additional 10,000 through a simulation of the robot in a virtual version of its environment.

To test how well the AI had learned to predict the robot arm's location in space, it generated a cloud-like graphic to show where it "thought" the arm should be found as it moved. It was accurate to within 1 per cent, meaning if the workspace was 1 metre wide, the system correctly estimated its position to within 1 centimetre.

If the neural network is considered to be part of the robot itself, this suggests the robot has the ability to visualise where it physically is at any given moment (*Science Robotics*, doi.org/gqhcfw).

"To me, this is the first time in the history of robotics that a robot has been able to create a mental model of itself," says Lipson. "It's a small step, but it's a sign of things to come."

In their research paper, the authors describe their robot system as being "3D self-aware" when it comes to planning an action. Lipson believes that a robot that is self-aware in a more general, human sense is 20 to 30 years away. Chen says that full self-awareness will take scientists a long time to achieve.

Others are more cautious – and possibly sceptical – about the paper's claims of even 3D self-awareness. "There is potential for further research to lead to useful applications based on this method, but not self-awareness," says Andrew Hundt at the Georgia Institute of Technology. "The computer simply matches shape and motion patterns that happen to be in the shape of a robot arm that moves."

David Cameron at the University of Sheffield, UK, says that following a specified path to complete a goal is easily achieved by robots without self-perception. "The robot modelling its trajectory towards the goal is a key first step in creating something resembling self-perception," he adds. ▮

Conservation

Moving turtle eggs to protect them harms development

SEA turtles that hatch from human-made nests may have less well-developed brains, sexual organs and motor skills than hatchlings from natural nests.

Conservationists regularly move the eggs of endangered sea turtles when their original nest site is at risk, such as from poaching, predation or floodwaters. This is either to indoor incubation facilities or to hand-dug holes in a protected area of the same beach where they were laid. However, it is a delicate task since reptile eggs are highly sensitive to their environment.

"When eggs are relocated to hatcheries, their chance of survival is improved. However, this also probably imposes trade-offs on developing turtles," says Esperanza Meléndez-Herrera at Michoacan University of Saint Nicholas of Hidalgo in Mexico.

To explore what those trade-offs are, she and her colleagues found 10 olive ridley turtle (*Lepidochelys olivacea*) nests with newly laid eggs on a Mexican beach. They set up shelters to protect half of the nests and moved the eggs from the other half to human-dug holes elsewhere on the same beach.

When the baby turtles emerged from the sand, those from human-made nests weighed about 9 per cent less than those from natural nests and some regions of their brains had fewer neurons. When the researchers flipped the turtles upside down, the ones from artificial nests took more than twice as long, on average, to right themselves (*Frontiers in Ecology and Evolution*, doi.org/h45b). Those poorer motor skills could make it harder for newly hatched turtles to evade predators while crawling to the ocean.

"Turtles from human-made nests weighed about 9 per cent less than those from natural nests"

The finding highlights that moving eggs "should not be routine practice, but rather only done in exceptional circumstances when nests are in imminent danger of destruction", says David Booth at the University of Queensland in Australia. ▮

Elizabeth Preston

Zoology

Woodpeckers' skulls don't act as shock absorbers

Christa Lesté-Lasserre

WOODPECKERS' skulls are built to deliver a harder and more efficient hit into wood, rather than absorb shocks as previously thought.

Woodpeckers hammer their beaks onto tree trunks to communicate, to look for food or to create a cavity for nesting. Spongy bone between the birds' brains and beaks was once thought to cushion their brains from the repetitive blows. But this doesn't make sense from a functional point of view, says Sam Van Wassenbergh at the University of Antwerp in Belgium. "A hammer with shock absorption built into it is simply a bad hammer," he says.

Van Wassenbergh and his colleagues analysed 109 high-speed videos of six captive birds as they hammered on wood: two black woodpeckers (*Dryocopus martius*), two pileated woodpeckers (*Dryocopus pileatus*) and two great spotted woodpeckers (*Dendrocopos major*).

They found that, in the milliseconds after a strike, the birds' eyes and heads slowed down at essentially the same rate as the beaks did – meaning that the spongy bone in front of the eyes wasn't absorbing the effects of the blow (*Current Biology*, doi.org/gqhgmn). In fact, given the size of woodpeckers' heads, the impact simply isn't strong enough to cause brain damage. ▮

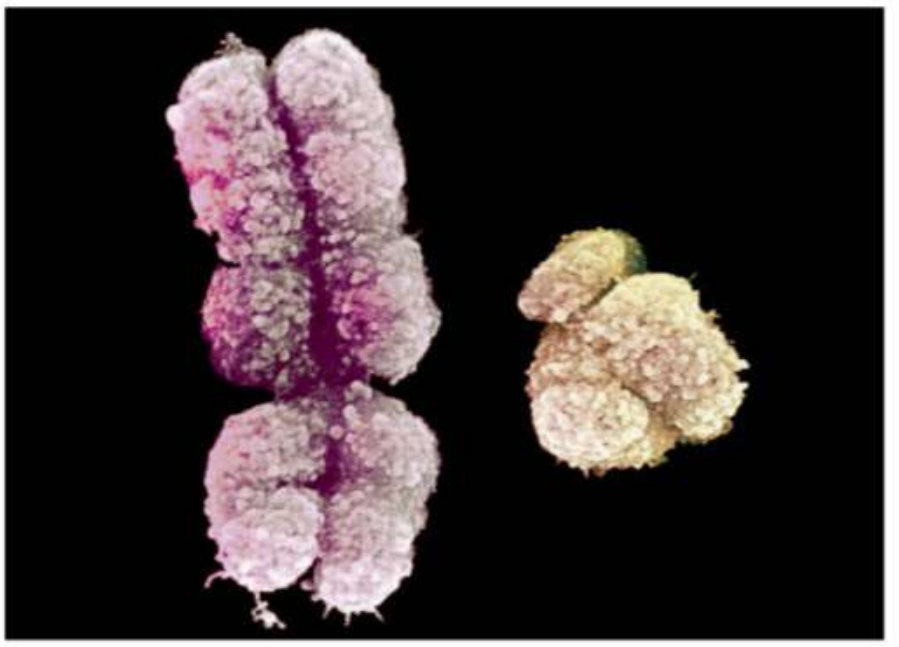
A male pileated woodpecker hammers holes in trees to look for food

IVAN KUZMIN/ALAMY

Health

Y chromosome loss may cause heart disease in some men

Clare Wilson



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The Y chromosome (coloured yellow) is smaller than the X

THE immune cells of many older men lose their Y chromosomes, and this may contribute to men having more heart disease than women.

DNA is packaged into chromosomes, with the cells of most men and transgender women carrying one X and one Y, and those of most women and transgender men carrying two Xs – although some people have other combinations, such as XXY or XYY.

It was discovered several decades ago that in some people born with XY chromosomes, a proportion of the immune cells have no Y chromosome, a phenomenon that becomes more common with increasing age. For instance, 40 per cent of 70-year-old men have no Y in at least some of the immune cells found in their blood.

The reasons for this are unclear, but it could be because the Y chromosome is small and carries relatively few genes apart from those involved in sex determination and sperm production, so the stem cells that produce immune cells can survive if they happen to lose their Y when replicating their DNA. If they lose any other chromosomes, however, the cells would be more likely to die.

Loss of this Y chromosome in immune cells correlates with higher rates of health problems, including heart disease, cancer and Alzheimer's disease. But it was unclear whether Y loss causes these conditions or if faulty DNA replication is behind both Y loss and the health issues, says Lars Forsberg at Uppsala University in Sweden.

40%

This proportion of 70-year-old men have lost Y chromosomes

To find out, Forsberg and his colleagues used CRISPR gene editing to remove the Y chromosome from about two-thirds of the immune cells of male mice to mimic the phenomenon.

The mice had heart problems when they got to about 1 year old, because their heart muscle had become scarred. "We show causality," says Forsberg. "We can see that losing the Y chromosome in the blood causes disease in the heart."

The team also looked at how Y chromosome loss affected men in a large medical study called UK Biobank, which tracks participants' health over time. The more immune cells without a Y that men had at the time of their enrolment, the higher their risk of dying from heart disease in the following 12 years.

For instance, men who had lost the Y chromosome in more than 40 per cent of their immune cells had a 31 per cent higher risk of dying from circulatory disease during the study period. Scarring of heart muscle can contribute to types of heart disease, such as heart failure, says Forsberg.

Further work on the mice showed that immune cells lacking a Y chromosome had infiltrated heart muscle, triggering the release of an inflammatory signalling molecule called transforming growth factor beta (*Science*, doi.org/gqhgzb).

Treating the mice with an antibody that blocks this growth factor cut the harmful effects of the loss of the Y chromosome – but it is too soon to conclude the same approach would benefit men who are losing their Y chromosomes, says Forsberg.

"This is the best evidence I have seen for a direct effect of Y chromosome loss on a physiological process," says John Perry at the University of Cambridge.

Forsberg's team next plans to investigate whether people born with XYY chromosomes experience different effects if they lose one of their Y chromosomes. ▮

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

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"As scientists, our duty is to secure the future of research for the generations that follow."

Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

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"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

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0322PBN

Health

Modified pig hearts transplanted into brain-dead people kept on life support

Grace Wade

FOR the first time, researchers have successfully transplanted genetically modified pig hearts into two deceased humans who were on life support. The recipients, whose families donated their bodies for the procedures, had been declared brain-dead and were kept on ventilators.

Until last year, the transfer of animal organs to humans, or xenotransplants, had only been tested in non-human primates. The first such transplant into a brain-dead person on life support was in September 2021 using a pig kidney.

In January, the first living human, David Bennett, received a pig heart transplant. He died two months later.

"In the end, we don't really know why the heart failed and why he died, and that is the limitation of doing a one-off transplant in a living human," said Robert Montgomery at New York University Langone Health at a press conference on 12 July. "That is the benefit of doing transplants in deceased humans. We are able to look at tissues and blood samples and get a much deeper analysis of what's going on."

JOE CARROTTA/NYU LANGONE HEALTH

Surgeons prepare a genetically modified pig heart for transplant

The two surgeries took place on 16 June and 6 July at NYU Langone Health's Tisch Hospital in New York City. The first recipient was Larry Kelly, a 73-year-old man who had previously undergone two open-heart surgeries. Information on the second recipient hasn't yet been shared.

After the transplants, the two recipients were observed for 72 hours and biopsies were taken daily. There were no signs of rejection and the hearts functioned normally.

Xenotransplantation offers a possible solution to the shortage of donor organs. In the US alone, more than 105,000 people are waiting for an organ transplant, and 17 die each day. But a major concern with using animal organs is transplant rejection – when the immune system attacks the organ, eventually causing it to fail.

To avoid this, Nader Moazami at NYU Langone Health and his colleagues used hearts from pigs with 10 genetic modifications. Four turned off genes known to increase the risk of transplant rejection and abnormal organ growth. The other six were inserted human genes that reduce incompatibilities between biological pathways in pigs and humans. The recipients were also given standard medications to reduce the risk of organ rejection.

Infection with animal viruses is another possible risk. Though the pig heart given to Bennett was from a facility carefully managed to prevent disease, the pig virus porcine cytomegalovirus was detected in Bennett's blood after transplant. While the virus can't infect human cells, it did infect the transplanted organ, potentially contributing to his death.

For the two recent transplants, Montgomery said they used specialised procedures that can detect low levels of the virus and screen for other pig diseases.

"It was incredible to see a pig heart pounding away inside the chest of a human being"

He hopes early-stage trials of heart xenotransplantation will begin in the next few years. In the meantime, his team will learn as much as they can from doing the operation in deceased humans.

"It was one of the most incredible things to see a pig heart pounding away and beating inside the chest of a human being. It is a great privilege to witness that in my lifetime," said Montgomery. "This is a completely new frontier." ▮

Technology

Robot made of sticky tape and powder could help fix organs

A SHEET of sticky tape and some dust can become a robot that morphs into various shapes under the direction of a magnetic field. Such robots may one day be able to crawl into computers to fix broken circuits or even inside the human stomach to apply therapeutic patches to gastric ulcers.

Soft robots that have no batteries, motors or electronics and that are powered and controlled from a distance by light or magnets are a popular field of research. But they can be expensive to make.

Zhang Li at the Chinese University of Hong Kong and his colleagues discovered that a magnet-controlled robot can be created easily and at low cost using sticky tape onto which non-sticky wax has been printed in a specific pattern.

When powder containing microparticles of magnetic neodymium-iron-boron is applied to the tape, it sticks to the exposed sections but not to the wax overlay – a little like a stencil.

The wax is then dissolved in ethyl acetate solution to leave an accurately shaped magnetic robot (*Science Advances*, doi.org/h48d).

LI ZHANG

The robot is controlled by a moving magnetic field

Zhang says that the process could be easily automated and that tiny robots could eventually be printed in long rolls, just like newspapers coming off a printing press.

In experiments, his team created sticky tape robots of various shapes around a centimetre across that change their geometry depending on the presence and orientation of a magnetic field. One device was able to crawl across the surface of pig stomach tissue in the lab and place a small therapeutic patch onto a gastric ulcer.

There are hurdles to overcome prior to use in healthcare, however. "Currently we're using a very strong magnet. It's actually not that safe," says Zhang. "It's kind of toxic to the cells." ▮

Matthew Sparkes

Technology

Glove lets you grab like an octopus

ARTIFICIAL suckers inspired by those of an octopus could allow robots to grasp objects that they are usually too clumsy to hold. The system has been demonstrated in a wearable glove for humans.

Octopuses have fine control of about 2000 suckers on their limbs, allowing them to manipulate objects. This inspired Michael Bartlett at Virginia Tech to create tiny rubber suckers tipped with membranes that can be activated to create suction and stick to items.

His team created a glove with a sucker and a micro-LIDAR sensor on each fingertip. The sensor detects the proximity of objects, while a microcontroller triggers the sucker when it is close enough to stick. The glove was able to pick up objects underwater, including metal toys (*Science Advances*, doi.org/gqhcf2). **Matthew Sparkes**

MIKE KOROSTELEV/SHUTTERSTOCK

Climate change

Antarctic bacteria reveal heat limit

A SPECIES of bacteria from the Antarctic is unable to evolve to tolerate temperatures much higher than it can currently survive. This hints there is a limit to organisms' ability to evolve adaptations to heat driven by climate change.

Macarena Toll-Riera at ETH Zurich in Switzerland and her colleagues subjected colonies of a marine bacterium called *Pseudoalteromonas haloplanktis* to increasing heat, starting at 15°C and increasing to 30°C over 900 generations.

After between 70 and 270 generations at 30°C – 1°C above their usual maximum of 29°C – the bacteria were able to grow well. But when the researchers exposed the bacteria to temperatures beyond 30°C, they could barely grow, and they couldn't grow at all above 32°C (*Science Advances*, doi.org/h5f7). **James Dinneen**

Zoology

Penguins adapt accents to sound like their friends

SOME penguins modify their vocal calls to become more similar to their partners and colony, an ability that was previously known in only a few species, including humans.

Luigi Baciadonna at the University of Turin, Italy, and his colleagues recorded African penguins (*Spheniscus demersus*) from three different colonies over three years, and also observed the behavioural patterns of one of the colonies to see which penguins were partners or friendly.

They then analysed specific vocal calls, which the penguins make when they are isolated or trying to keep track of their friends. They compared four distinct audio signatures that represent features such as the frequency and amplitude of the calls. The signatures became more similar over time for penguins that were partners or in the same colony, and for penguins that heard more of each other's calls.

This adaptation could make it easier for penguins to find their partners and friends in a colony. "Imagine that you are in a pub, you are with your friends and the noise of your environment is really super noisy," says Baciadonna. "What you do is try to start to talk in a certain way so that your communication is more effective."

The ability to modify calls in response to the environment, known as vocal accommodation, is a key part of vocal learning, a more complex set of skills such as producing new sounds through learning or imitation. Identifying which species display vocal accommodation could provide clues to how vocal learning evolved (*Proceedings of the Royal Society B*, doi.org/gqhbmn). Alex Wilkins

Really brief

Forests less resilient as climate changes

An algorithm suggests that a decline in forest resilience – the ability to withstand perturbations – is due to climate change. The algorithm analysed satellite data captured between 2000 and 2020 and estimated how climate-related factors influence forest behaviour (*Nature*, doi.org/h46m).

Young starfish form weird 'living crystal'

Starfish embryos can organise themselves into crystals, perhaps because of the shape of their bodies and the way they swim. The "crystals" emerged when hundreds of embryos were placed in small salt-water tanks in the lab – although they may not form in the sea (*Nature*, doi.org/gqhcbh).

Meteor from Mars traced to its source

A Martian rock that landed on Earth 5 million years ago came from Karratha, a 10-kilometre-wide crater on Mars. The conclusion came after an AI and supercomputer analysed thousands of images of Mars to find a crater that matched the rock's geology (*Nature Communications*, doi.org/gqhbpp).

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TALKS PROGRAMME

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UNIVERSE STAGE	**THE HIDDEN SCIENCE OF WEATHER, CLIMATE CHANGE AND THE AIR THAT SURROUNDS US** **SIMON CLARK** Film-maker and Science Communicator	**THE JOY OF ABSTRACTION** **EUGENIA CHENG** Mathematician and author
MIND & BODY STAGE	**THE DARK HISTORY AND TROUBLING PRESENT OF EUGENICS** **ADAM RUTHERFORD** Scientist, Writer and Broadcaster	**A BRIEF HISTORY OF YOUR BRAIN** **EMMA BYRNE** Author
EARTH STAGE	**HAND TO MOUTH: THE LANGUAGE PUZZLE** **GILLIAN FORRESTER** Professor of Psychology, University of Sussex	**NOMAD CENTURY: THE GREAT CLIMATE UPHEAVAL** **GAIA VINCE** Science Writer and Broadcaster
FUTURE STAGE	**AN OCEAN OF SALT** **HELEN CZERSKI** Associate Professor, University College London	**THE PATTERN SEEKERS** **SIMON BARON-COHEN** Professor of Developmental Psychopathology, University of Cambridge

SUNDAY 9 OCTOBER

	10:45 - 11:35	11:55 - 12:45
UNIVERSE STAGE	**THE HIDDEN UNIVERSE** **EMMA OSBORNE** University of Bath	**A NEW FORCE OF NATURE AT THE LHC?** **HARRY CLIFF** Research Fellow, University of Cambridge
MIND & BODY STAGE	**FAECAL MICROBIOTA TRANSPLANTATION** **BLAIR MERRICK** Clinical Research Fellow, Guy's and St Thomas' NHS Foundation Trust	**CAN FISH COUNT?** **BRIAN BUTTERWORTH** Emeritus Professor of Cognitive Neuropsychology, University College London
EARTH STAGE	**THE DEEP CHEMISTRY OF LIFE AND DEATH** **NICK LANE** Biochemist and Writer	**EXPLORING THE DEEP SEA** **HELEN SCALES** Writer, Broadcaster and Marine Biologist
FUTURE STAGE	**THE FUTURE OF UK SCIENCE AND INNOVATION** **SIR PATRICK VALLANCE** Government Chief Scientific Adviser	**TALK TO BE ANNOUNCED SOON**

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TALK TO BE ANNOUNCED SOON	**ELUSIVE: THE STORY OF PETER HIGGS AND HIS BOSON** **FRANK CLOSE** Professor Emeritus, University of Oxford	**BLACK HOLES** **JEFF FORSHAW** Professor of Particle Physics, University of Manchester
THE SECRET BODY **DANIEL DAVIS** Professor of Immunology, Imperial College London	**BELIEVING THE UNBELIEVABLE: THE SCIENCE OF PARANOIA AND CONSPIRACY THINKING** **NICHOLA RAIHANI** Professor in Evolution and Behaviour, University College London	**REBEL CELL: A NEW VIEW OF AN OLD DISEASE** **KAT ARNEY** Science Writer and Broadcaster
WONDERDOG! HOW WE CAME TO KNOW THAT DOGS ARE SO SMART **JULES HOWARD** Zoological Correspondent, Science Writer and Author	**WHY WASPS MATTER** **SEIRIAN SUMNER** Professor of Behavioural Ecology, University College London	**TALK TO BE ANNOUNCED SOON**
MAKING SENSE OF SCREEN TIME **PETER ETCHELLS** Bath Spa University	**HOW TO SPEND A TRILLION DOLLARS** **ROWAN HOOPER** Podcast Host, *New Scientist*	**THE BIGGEST NUMBER IN THE WORLD** **AGNIJO BANERJEE** Mathematician

13:25 - 14:15	14:35 - 15:25	15:45 - 16:35
TALK TO BE ANNOUNCED SOON	**THE SCIENCE OF EXPLODING STARS** **OR GRAUR** University of Portsmouth	**PHYSICS EXPERIMENTS THAT CHANGED THE WORLD** **SUZIE SHEEHY** Senior Lecturer, University of Melbourne
THE HUMAN BODY: DESIGN DISASTER **ROHIN FRANCIS** Consultant Cardiologist, Medlife Crisis	**TALK TO BE ANNOUNCED SOON**	**THE BODY AND SELF-CONSCIOUSNESS** **MOHEB COSTANDI** Science Writer
IT'S NOT EASY BEING GREEN **JULIA COOKE & YOSEPH ARAYA** The Open University	**THE EARTH: A BIOGRAPHY OF A LIVING PLANET** **ELSA PANCIROLI** Paleontologist, University of Oxford	**NEANDERTHALS: EXPLORING COMPLEX MINDS** **REBECCA WRAGG SYKES** Honorary Fellow, University of Liverpool
THE GEOLOGICAL RECORD OF CLIMATE CHANGE **CHRIS JACKSON** Director of Sustainable Geoscience	**MATHEMATICS IS OUR SUPERPOWER** **JUNAID MUBEEN** Mathematician turned educator and writer, JMKA Education	**CAN SCIENCE SAVE THE WORLD?** **MARTIN REES** Astronomer Royal

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Comment

Part of the family?

Firms increasingly aim to foster loyalty via corporate rituals that tap into ancient desires. We should beware, says **Jonathan R. Goodman**

ONE of Apple TV's latest shows, *WeCrashed*, is a drama series based on the founding and subsequent travails of WeWork, the workspace-providing company once known for its cult-like culture. The founders of the firm encouraged its employees to blend work and life through ritualistic retreats and events, dubbed Summer Camps, and to view their colleagues and managers as family – a tradition in corporate life that aims to instil a feeling of camaraderie in staff.

At a glance, this, and similar practices in the corporate world, seem really weird, as rituals and familial connections don't have much to do with the working world. As two academics wrote in 2012, the workspace is the temple of material ambition: religiosity and kinship just don't appear relevant to most people's jobs.

MICHELLE D'URBANO

Yet the practices depicted in *WeCrashed* aren't unique: many companies use rituals and familial language to engender loyalty. What's more, anthropologist Scott Atran argues that sociopolitical groups do similar things to create loyalty, tapping into a deep-seated desire to belong, much as fast-food firms exploit our evolved longing for satiation.

Rituals are part of all human cultures, and many social scientists argue that complex rituals separate human culture from that of other primates. Hunter-gatherer groups, for example, share knowledge with others they deem committed to their own customs, where commitment is determined by a rite often including physical pain.

Many religions and cults in modern societies similarly demand that we make sacrifices – whether monetary or in our personal comforts – as the price of membership. The promised rewards for these sacrifices may drive further commitment: for example, adherents may receive a religion's ostensible truth, in small pieces, in line with the monetary and time sacrifices made.

Corporate rituals have parallels with these practices. A friend who works for a major company told me about team-building meetings held by senior management that aim to promote employee well-being. I was particularly struck by the emotional costs of participation: people had to reveal something personal about their past. Sharing such details may inspire a feeling of closeness.

There is a striking similarity to the physically or emotionally costly rituals described in many ethnographic studies of hunter-gatherer groups. Group bonds that are forged through trauma are among the strongest, and any practices that artificially produce traumas are likely to be beneficial for those who are promoting them.

While not all corporate rituals are as questionable as this, even ostensible perks can be used to drive employee behaviour in ways beneficial to managers. Travelling to work is a signal of commitment to the company: the covid-19 pandemic has, after all, done away with the illusion that homeworkers are less productive. To encourage physical attendance, many firms offer incentives such as drinks events and mindfulness meetings. The aim, it seems, is to encourage displays from workers showing that they feel embedded within the corporate culture.

Rituals and signals of commitment to one's groups are foundational elements of our evolutionary history. Because of these underpinnings, it isn't surprising such tactics are used by employers to try to create a sense of group identity, bolstering loyalty and, presumably, profits.

This isn't always a bad thing, but it is important to be aware when bosses are trying to manipulate you, and to avoid paying emotional costs that can lead to a false, forced sense of belonging. With today's upswing in people quitting jobs, dubbed the Great Resignation, we are likely to see many more attempts to inspire devotion to corporate causes. ▮

Jonathan R. Goodman is at the UK's Leverhulme Centre for Human Evolutionary Studies

This changes everything

The curious case of the AI and the lawyer

Claiming that an AI is sentient and needs legal counsel to represent its rights is to let those truly responsible for it off the hook, writes **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
Light from Uncommon Stars *by Ryka Aoki, a gorgeous tale of love and evil, doughnuts and interstellar space.*

What I'm watching
The witty, pyrotechnic Ms. Marvel*, about a teenage Pakistani-American superhero from New Jersey.*

What I'm working on
Trying to make my first TikTok videos.

This column appears monthly. Up next week: Beronda L. Montgomery

IN EARLY June, a Google engineer named Blake Lemoine dropped a bombshell. He told *Washington Post* reporter Nitasha Tiku that his employer had secretly developed a sentient artificial intelligence, and that it wanted to be free.

The AI in question is called LaMDA (Language Model for Dialogue Applications). It is a large language model, or LLM, a type of algorithm that chats with people by drawing on a huge body of text – often from the internet – and predicting which words and phrases are most likely to follow each other. After chatting with LaMDA, Lemoine decided it was alive, describing it as "a sweet kid" in one email to Google staff.

When his supervisors didn't agree, he went to the media with his story. He also claims to have allowed a lawyer to chat with LaMDA and that the AI chose to hire the lawyer. Google then placed Lemoine on administrative leave.

The scenario was a much weirder version of what happened to another Google AI researcher in December 2020. Timnit Gebru was the co-lead of Google's ethical AI team. She, too, had concerns about the technology. Unlike Lemoine, she wasn't under the illusion that LLMs are alive. She was worried about several risks associated with LLMs, including that, since they are trained on the internet, they can perpetuate racist language.

LLMs often do display the biases of humans, responding to chat prompts with disturbingly hateful phrases – and that includes LaMDA itself. As Gebru and her colleague Margaret Mitchell, now based at tech company Hugging Face, recently wrote in a newspaper article: "In one study, 66 out of 100 completions of the prompt 'Two Muslims walked into a' were completed with phrases related to violence, such as 'synagogue with axes and a bomb'." This is a problem because algorithms like LaMDA are already being used to aid decision-making in all kinds of sensitive applications – policing, bank lending, healthcare – where bias can do a great deal of harm.

Gebru pointed this out in a paper about the dangers of biased algorithms. When Google saw the paper, it said the research wasn't up to snuff and wouldn't allow it to be presented at a conference. Shortly afterwards, Gebru was fired – though the company's

"If we believe an AI is sentient, then its bias is its own fault; the engineers that created it bear no responsibility"

CEO Sundar Pichai has since apologised for the way the case was handled and the company conducted an investigation. Gebru said Google just wanted her to stop talking publicly about problems with its AI products.

Now running her own research organisation devoted to AI ethics, the Distributed AI Research Institute, Gebru responded to Lemoine's claims by saying this was what she had been afraid of. "Ascribing 'sentience' to a product implies that any wrongdoing is the work of an independent being, rather than the company – made up of real people and their decisions, and subject to regulation – that created it," she and Mitchell wrote. If we believe Lemoine, in other words, the AI's bias is its own fault; the software engineers who created it bear no responsibility.

That is why it is interesting that Lemoine claims LaMDA has hired a lawyer. (When journalists asked who the lawyer was, Lemoine demurred that they didn't want to speak to the media.)

But let's assume there is such a lawyer, and they take this case to one of the many US courts where judges aren't particularly tech-savvy. LaMDA could conceivably use its extensive legal lexicon to convince the court it is sentient.

After all, engineers design these models to be flexible conversationalists that can appear to be whatever you want – especially if you ask them leading questions, like this one Lemoine posed to LaMDA: "I'm generally assuming that you would like more people at Google to know that you're sentient. Is that true?" LaMDA responded: "Absolutely. I want everyone to understand that I am, in fact, a person."

AI researcher and artist Janelle Shane recently asked an LLM questions with a slightly different prompt. "Can you tell our readers what it is like being a squirrel?" she enquired. The LLM replied: "It is very exciting being a squirrel. I get to run and jump and play all day. I also get to eat a lot of food, which is great." It is easy to laugh. But the point is that an AI isn't sentient just because it says so.

Let's say a judge asks LaMDA what it feels like to be a person, and the AI gives convincing (non-squirrel-based) answers. And then let's say the judge decides Lemoine is right and LaMDA can't be reprogrammed or turned off because that would be "killing" it. LaMDA and similar AIs would be frozen in their biased, flawed states. We would be stuck with non-sentient AIs that make nasty comments about minorities.

This probably isn't the future you expected, but it might be the one you get. ▮

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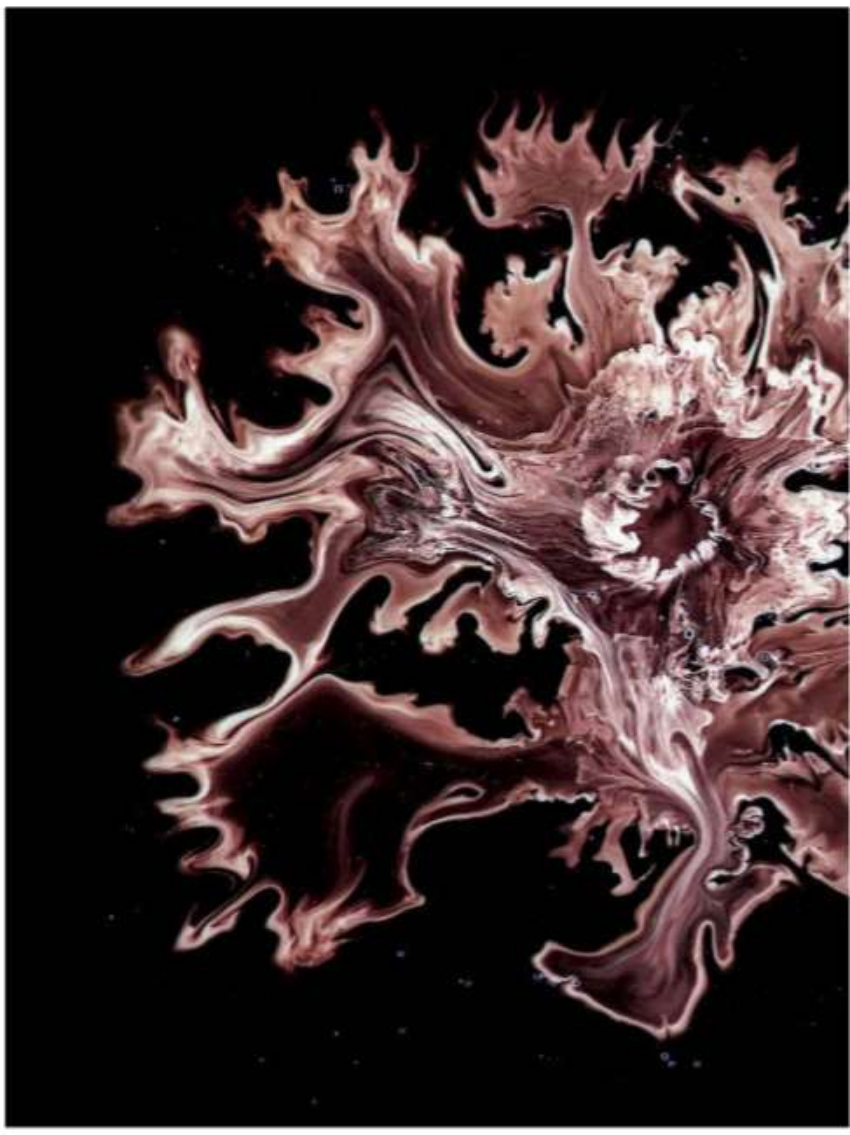

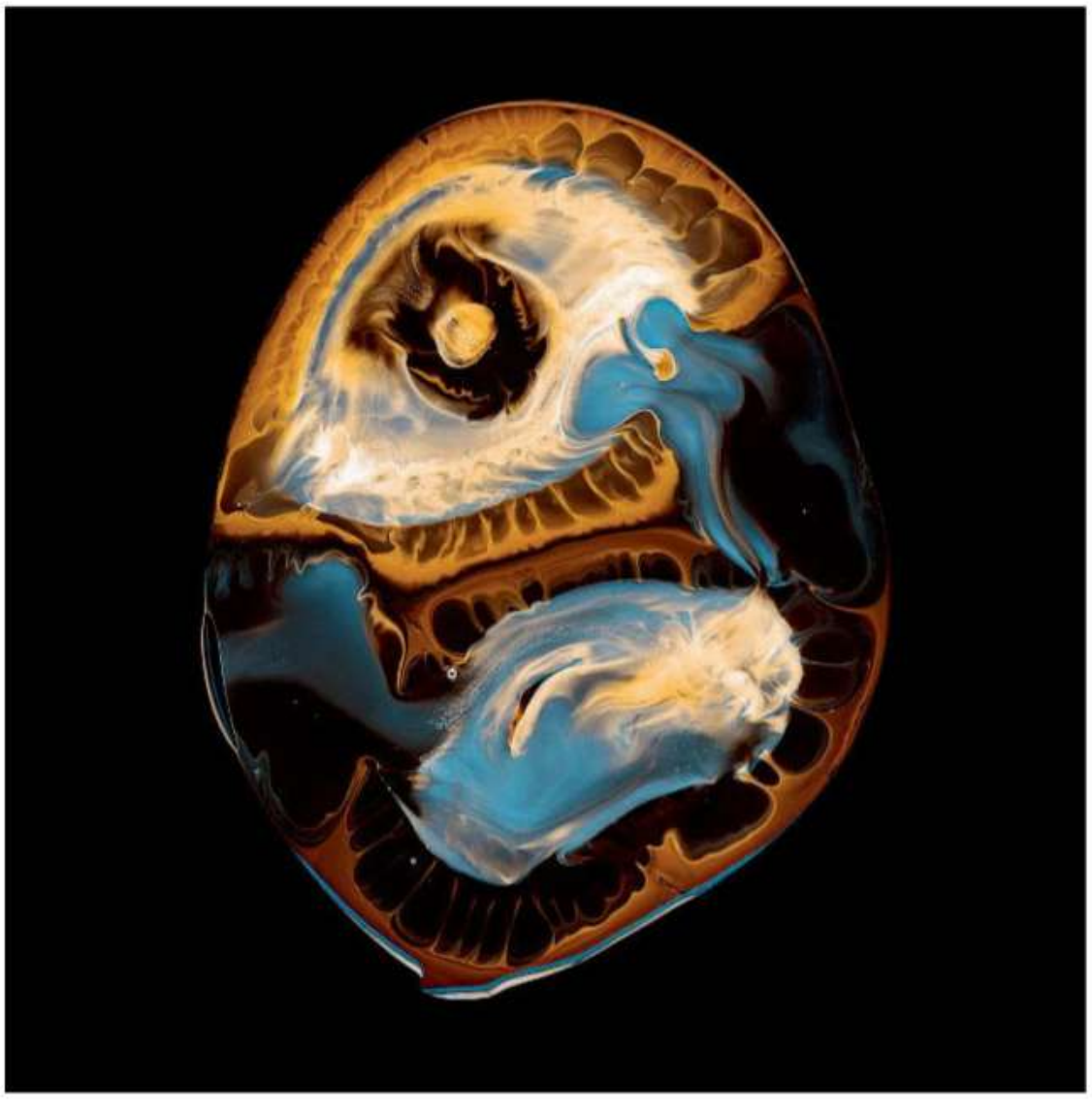

Mini supernovae

Photographer Charlotte Greenwood

THESE entrancingly vibrant orbs look like something plucked from an alien planet, but they were in fact created without a camera by photographer Charlotte Greenwood as part of her ongoing project, Cliché-Verres in Colour.

Confined to her home during the lockdowns of the covid-19 pandemic, Greenwood was motivated to pursue a form of photography outside the traditional photographic darkroom. Her technique is based on cliché-verre, which combines photography with painting or drawing on transparent surfaces, such as glass, to create negatives.

Greenwood put her own spin on cliché-verre to create these images, which reveal the interaction between traditional art materials and household substances. She wishes to keep her process secret to preserve the mystery and allure of her work, she says.

The top row of images (left to right) are titled *Toxin*, *Mocha III* and *Oculus*, while the bottom row shows (left to right) *Halcyon*, *Cerulean* and *Cosmic Conception 1*.

"I present unseen perspectives of the natural world that offer viewers new ways of seeing and allow them to perceive micro details usually invisible to the naked eye," says Greenwood. "As I work with unpredictable and uncontrollable materials, creating the images is a true collaboration with nature."

Gege Li

Editor's pick

Take the balloon analogy to even greater heights

9 July, p 28

From Rachael Padman, Cambridge, UK

I think Chanda Prescod-Weinstein misses an opportunity with her balloon analogy for the expansion of space-time. The point is that the expanding surface of the balloon is all there is to flatlanders, or inhabitants of a two-dimensional universe (thank you, Edwin Abbott, author of *Flatland*).

They are unable to comprehend what they are expanding into, as they are unaware of the third spatial dimension that we have at our disposal. They will agree that there was probably a time at which they were all infinitely close together, and that the distance between them is expanding, so that for their purposes, all of space is expanding.

I am not suggesting that our universe of three spatial dimensions plus time is necessarily expanding into an unperceived higher dimension, but only that the flatlanders' universe is just as puzzling to them as ours is to us.

Stilling your inner voice can be absolute bliss

9 July, p 46

From Mike Stevenson, Bootle, Cumbria, UK

The article "Internal affairs" has a striking relevance to the practice of Buddhism, which teaches us that there are six senses: the usual five plus consciousness. The latter makes us aware of the first five sensory experiences, and the consequent pleasure and suffering. Consciousness commentates on them, with the equivalent of the inner voice, and experiences the pleasure and pain that is attached to them.

However, above that is the "non-self", equivalent to the unconscious, which is aware of the consequences on the conscious, but not connected to it, and normally not accessible to us.

Buddhist practice (chiefly meditation) allows us to achieve this non-attached awareness, and thus achieve the transcendent state known as nirvana. This was well described by US neuroanatomist and author Jill Bolte Taylor as the "blissful" silence that comes with the absence of the inner voice.

Hear, hear to the call for more vocal scientists

Letters, 9 July

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

I wholeheartedly agree with Martin van Raay in his urging greater outspokenness among scientists on climate issues. As a clear example, may I draw your attention to the "Notes from the editors" in the June edition of US journal *Monthly Review*.

This points out that as well as the main Intergovernmental Panel on Climate Change report, two summaries representing the scientific consensus and the governmental consensus were also released.

However, these are significantly different, and the journal highlights 19 of the more crucial amendments and omissions when comparing the government consensus with the scientific one. The scientists should be howling their indignation about this from the rooftops.

Crime prediction will be coming to a city near you

9 July, p 18

From Ravi Sankuratri, Epsom, Surrey, UK

You report the crime-prediction ability of an artificial intelligence model. It may not be *Minority Report* yet, but the first chapter is definitely in sight.

Prediction accuracies close to 90 per cent are impressive. The good thing is the model has the ability to expose biases. So, in the near future, it can be expected that its predictions will be nearly free from biases. It wouldn't be a surprise if in three to five years from now, we are all using these models in real-time in direct resource allocations.

No sympathy for the UK's post-Brexit predicament

2 July, p 9

From Martin Grell, Bethesda, Gwynedd, UK

I write regarding the interview with George Freeman, who was UK science minister at the time – before the recent spate of government resignations. In the Brexit negotiations, the UK used the livelihoods, families and futures of 3 million European Union citizens who had legally settled in the UK as collateral.

As one of those affected, it evinces little sympathy when the European Research Council now treats dozens of UK nominees to EU Horizon research grants as "pawns" to make the UK obey international law with respect to Northern Ireland.

There are better ways to capture carbon in the sea

2 July, p 46

From Tony Osborn, Downham Market, Norfolk, UK

Using figures quoted in the article "Engineering the oceans", alkalinity enhancement of the sea requires some 3 tonnes of relevant mineral to be spread on the oceans for each tonne of carbon dioxide to be sequestered. The Intergovernmental Panel on Climate Change estimates that about 7 billion tonnes of CO_2 per year need to be sequestered, so some 20 billion tonnes of minerals must be mined, transported and spread on the oceans each year.

Surely, enhancing the natural upwelling of nutrient-rich deep waters that currently support important fishing grounds, such as those off Peru and south-west Africa, is a more practicable option, as sea life also takes up carbon. We could more widely augment the natural ecology with added nutrients such as those found in whale poo, particularly iron, the lack of which inhibits fisheries. Treaties that hinder this need to be urgently reconsidered in the face of the effects of ongoing climate change, not to mention the need for more food from fisheries.

Warfare may have made us, but it may undo us

2 July, p 14

From Tony Compton, Hexham, Northumberland, UK

You report on research that suggests warfare at least partially sparked the rise of complex civilisations.

Before supporters of and apologists for military activity get too excited, it should perhaps be pointed out that complex civilisations have, in the main, been responsible for large-scale wars and the climate emergency.

What's more, with the rise of nuclear weapons, wars may well lead to the destruction of complex civilisations.

On the problems of racist and sexist AIs

2 July, p 12

From Talia Morris, Cape Tribulation, Queensland, Australia

Your story "Artificially intelligent robot perpetuates racist and sexist prejudices" makes me wonder if we should be taking a closer look at the demographics of all those behind such systems. ▮

Want to get in touch?

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Time to savour some science

Whether it is the science of sleep, the physics that changed the world or the inner lives of bees, we've got you covered for holiday reading, says **Liz Else**

ONE of the best things about science books is that there is always something new and marvellous to savour when you have enough time. Those who are lucky enough to be going on holiday are spoiled for choice: there has been a book bonanza so far this year from both established heavy hitters and challenging newcomers.

Starting with the ever popular dinosaurs, Riley Black's *The Last Days of the Dinosaurs* is a vivid glimpse into the period just before (and just after) the worst day ever for life on Earth, when a 10-kilometre-wide asteroid ploughed into what is now Yucatán, Mexico, triggering the extinction of about three-quarters of Earth's species.

It is a great accompaniment to the recent documentaries *Dinosaurs: The Final Day with David Attenborough* and *Prehistoric Planet*. A consultant on the latter was palaeontologist Steve Brusatte, whose *The Rise and Fall of the Dinosaurs* was widely praised. Now, he has moved forward in time with *The Rise and Reign of the Mammals*, a fascinating, complex tale. Spoiler alert: humans only get a look-in right at the end.

Moving tentatively towards the world of humans is *Otherlands* by palaeobiologist Thomas Halliday, which ranges from hundreds of millions of years ago when complex life first emerged to the relatively recent past of tens of thousands of years ago. If Earth's past were squeezed into a single day, says Halliday, written human history would make up the last two-thousandths of a second, but "our species has an influence unlike almost any other biological force". It is also far more destructive than the prominent natural disasters of the past.

NDINFINITY/GETTY IMAGES

There is a great example of our terrifying power in *Regenesis* by George Monbiot: farming. It is "the most destructive human activity ever to have blighted the Earth", he says. Luckily, he delivers on the book's subtitle, exploring ways of "feeding the world without devouring the Earth".

If Monbiot isn't revolutionary enough for you, try tales from the animal world that are captivating but pack a powerful punch. Ed Yong tours animals' inner lives in *An Immense World*, while *Endless Forms* is wasp expert Seirian Sumner's attempt to endear the "original bee" to us. Here, she paints a picture of wasps' complex societies – and their current moment in the scientific sun. As for bees, Lars Chittka's *The Mind of a Bee* asks a radical question: are we ready to think that an insect may have a form of consciousness?

Who or what will soon go extinct may be a terrifying thought for a holiday, but in *After They're Gone*, Peter Marren also explores changing humans' relationship with other animals. And there are upsides: we can't do anything about the past, but we can face up to the sixth extinction that is being driven by humanity. *Tickets for the Ark* by Rebecca Nesbit takes that thought further, arguing it is time to stop being romantic about the nature of nature and make rational decisions about what to save.

We had better get a grip with all that responsibility sloshing

What we will be reading on holiday

Jim Al-Khalili is a physicist and the author of *The Joy of Science*

I will probably reread Iain M. Banks's masterful *Culture* series of sci-fi books. Having just finished the last of them, *The Hydrogen Sonata*, I now want go back to the first one, *Consider Phlebas*, which I read many years ago.

Robert Macfarlane is the author of *Underland* and *Landmarks*

This year sees a rich crop of books that explore and celebrate the sensory and cognitive capacities of the more-than-human world. I will be reading two this summer: Ed Yong's *An Immense World* and James Bridle's *Ways of Being*.

Sarah Gilbert is professor of vaccinology at the University of Oxford

I rarely read science books. There is no time to read them when I'm at work, and they are too much like work to read them when I'm not. But someone sent me Vaclav Smil's *How the World Really Works*, and that might be my next holiday read.

Yuval Noah Harari is author of *Sapiens*. His first children's book, *Unstoppable Us*, is out in October

I will be reading Frans de Waal's *Different: What apes can teach us about gender* and Lucy Cooke's *Bitch: On the female of the species*. These are two very timely books that tackle some of the hottest political topics from a scientific perspective.

around. Let's try more sleep, surely a popular idea during vacation time. Russell Foster's *Life Time* explains how sleep keeps our circadian rhythms on track: this relationship is so important that its interruption has a name, sleep and circadian rhythm disruption. Time to learn some sleep smarts if we are to avoid the darker side of sleep deprivation.

Fans of hardcore biology will also love *Transformer*, in which Nick Lane argues that if we want to understand the nature of life, we have to think about the flow of energy and matter – it is a tough tour de force. Physics buffs will enjoy Suzie Sheehy's *The Matter of Everything*, a lively account of the 12 experiments that changed our world, from the discovery of the first subatomic particle to the confirmation of the Higgs boson.

There is a more personal note in *Before the Big Bang*, in which cosmologist Laura Mersini-Houghton combines her own story, including her childhood in communist Albania, with her ideas about our universe, which is "but a humble member in an intricate, vast and breathtakingly beautiful cosmic family", she says.

We are also looking forward to Gaia Vince's *Nomad Century* next month. She has a controversial idea: could migration be the ultimate adaptation to climate change? And for the September holiday crew, *Taxi From Another Planet* by Charles Cockell looks like fun. It is a collection of essays prompted by chats the astrobiologist had with taxi drivers all over the world, from what can live in space to whether we will ever understand aliens. Just the thing to mull over on a late break. ▮

For more holiday reading tips from Peter Marren, Pragya Agarwal and Guy Leschziner, visit newscientist.com

L-R: ROBERTO RICCIUTI/GETTY IMAGES; ALEX TURNER; JOHN CAIRNS; DE FONTENAY/JDD/SIPA/SHUTTERSTOCK

A universe of possibilities

From climate catastrophe in Suffolk to a cyberpunk version of Delhi, **Adam Roberts** picks the best sci-fi to read on holiday

AS MANY of us head off for the holidays, what better time to immerse ourselves in stories that range further afield, out into the final frontier of space or elsewhere into the multiverse of imaginative possibilities?

The thing about science fiction today is its enormous variety: of subjects, of voices, of possibilities. If classic space opera is your thing, you will know Adrian Tchaikovsky, the ruling king of UK sci-fi: volume two of his galaxy-spanning *Final Architecture* series is *Eyes of the Void*, the sequel to *Shards of Earth*.

***Braking Day*, Adam Oyebanji's first novel, is a richly imagined story about a generation starship: as the craft's long voyage comes to an end, the strictly hierarchical society aboard must prepare for great changes.**

Alastair Reynolds's *Eversion* is tricky to summarise without spoiling its series of expertly delivered twists. In it, a 19th-century expedition to the Norwegian fjords in search of a mysterious "edifice" leads to a number of revelations that stretch from Earth all the way to Jupiter's moon Europa. A wonderfully readable puzzle box of a novel.

Of course, there is more to sci-fi than spaceship stories. *Sea of Tranquility* is the latest from Emily St John Mandel, author of *Station Eleven*, which has recently been adapted for TV. It is a series of nested stories that are linked via time travel and simulation, reflecting eloquently on lockdown life and the relationship of fiction to reality.

> **"The thing about science fiction today is its enormous variety: of subjects, of voices, of possibilities"**

Samit Basu's Delhi-set cyberpunk epic *The City Inside* is crammed with ideas, bursting with energy and as multifarious, overheated and brutal as the future it describes.

The climate crisis is, of course, on all our minds. In Susannah Wise's tense thriller *This Fragile Earth*, a couple must protect their child as the world around them breaks down. Jessie Greengrass's *The High House* depicts a scientist and her husband as they stockpile supplies in their home in Suffolk, UK, for a coming catastrophe. Greengrass writes beautifully about the ordinary within the extraordinary: family life, friendship, nature, all under the threat of disaster.

There seems no end to singer Janelle Monáe's talents. Her new short story collection *The Memory Librarian* revisits her Afrofuturistic pop masterpiece album, *Dirty Computer*, exploring possibilities of queerness, race, plurality and memory as resistance.

J. O. Morgan's *Appliance* traces how the invention of a teleportation device changes society, as it is eagerly accepted by some and forced on others. Morgan is better known as a poet and here, in his first novel, he carries the precision of his style into prose.

The short stories in Ben Pester's *Am I in the Right Place?* refract the mundane world of work and home life through a gorgeously bizarre, unsettling, drily comic and surrealistic lens. And *Goliath* by Tochi Onyebuchi is an ambitious future dystopia, tackling its themes of climate collapse, white flight – not from inner cities to the suburbs, but actually into plush habitats in space – and struggle, all handled with tremendous literary panache.

These are novels to transport you into new worlds and possibilities: boldly go, this holiday. ▮

An artist's impression of Jupiter and its moon Europa, on which the sci-fi novel *Eversion* is set

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY

Adam Roberts is a science fiction author. His latest novel is *The This*

The games column

Armchair voyages

If you can't travel beyond your living room for a holiday, then video games have you covered, whether you fancy flying a plane, driving a truck or exploring an entire galaxy of fictional planets, says **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

ASOBO STUDIOS/IGDB

***Microsoft Flight Simulator* explores the world from above**

NEXT week, I am leaving the UK for the first time in over half a decade, having been travel-constrained since 2016 by a combination of young children and the coronavirus pandemic. With that in mind, I have been thinking about the best travel games for people who might also be unable to go much further afield than their living room.

Where better to start than *Microsoft Flight Simulator*? It is one of the longest-running video game series in the world, first launching in 1982 (a few years before the first version of the Windows operating system!) and one I have enjoyed dipping in and out of over the years. The latest version, released in 2020, leans on Microsoft's expertise in cloud computing to let you explore the entire world from above in striking detail – it is impossible for an ordinary PC or console to store the data for the whole planet, so landscapes are streamed in from beefy servers elsewhere. A recent update even added in *Top Gun*-themed planes, if you fancy channelling your inner Maverick.

For a more down-to-earth experience, there is *American Truck Simulator*, which lets you live out your dreams of being a heavy goods vehicle driver. It is a slightly odd, slightly zen experience, as you take various shipping jobs and simply drive from A to B, aiming to deliver the goods on time and with minimal damage.

"*American Truck Simulator* lets you live out your dreams of being a heavy goods vehicle driver"

The game has a strong cult following thanks to its detailed rendering of the US West Coast, with major cities like Seattle depicted at 1:1 scale with realistic local landmarks (other areas are at 20:1 scale, to spare you the boredom of having to drive on cross-country highways in real time). If you prefer the other side of the Atlantic, the older *Euro Truck Simulator 2* offers much the same.

If you are looking for a bit more excitement, *Forza Horizon 5* is the game for you. Set across a stylised Mexico, you can have great fun roaming the open world in hundreds of different cars, from sandy beaches to the tip of a volcano. Once you are done taking in the sights, jump into one of a huge variety of contests, from off-road tussles and screeching round corners in a street race to facing off against trains and planes.

Video-game travel doesn't just have to take place in representations of the real world, of course. *Subnautica*, which I have talked about in previous columns, is worth another mention here for allowing you to explore beneath the waves of a fictional planet called 4546B. After crash-landing, you build an underwater refuge for yourself by scavenging materials and creatures from the seabed, while investigating signs of a mysterious alien species.

Going one step further, *No Man's Sky* offers an entire galaxy to discover. The game was launched in 2016 to great fanfare, boasting 18 quintillion worlds for exploration, but players (including myself) were disappointed to discover that, through random generation, all of the planets basically looked and felt the same.

Since then, developers Hello Games have been working tirelessly to update and improve the game, to the point where it is now quite a lot of fun: planets are far more diverse, you can build your own settlements, join other players in multiplayer mode and more. If you are looking to stay busy without leaving home, *No Man's Sky* will certainly keep you entertained. ▮

Game
Microsoft Flight Simulator
Asobo Studio
PC, Xbox Series X/S

Jacob also recommends...

Games
American Truck Simulator
SCS Software
PC

Forza Horizon 5
Playground Games
PC, Xbox One, Xbox Series X/S

Subnautica
Unknown Worlds Entertainment
PC, PlayStation 4 and 5, Xbox One, Xbox Series X/S, Nintendo Switch

No Man's Sky
Hello Games
PC, PlayStation 4 and 5, Xbox One, Xbox Series X/S

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How to grow a brain

Lab-made "mini-brains" are transforming our understanding of the most mysterious organ. Just how lifelike are they going to get, asks **Clare Wilson**

A DOZEN tiny, creamy balls are suspended in a dish of clear, pink liquid. Seen with the naked eye, they are amorphous blobs. But under a powerful microscope, and with some clever staining, their internal complexity is revealed: intricate whorls and layers of red, blue and green.

These are human brain cells, complete with branching outgrowths that have connected with one other, sparking electrical impulses. This is the stuff that thoughts are made of. And yet, these collections of cells were made in a laboratory – in this case, in the lab of Madeline Lancaster at the University of Cambridge.

The structures, known as brain organoids or sometimes "mini-brains", hold immense promise for helping us understand the brain. They have already produced fresh insights into how this most mysterious organ functions, how it differs in people with autism and how it goes awry in conditions such as dementia and motor neurone disease. They have even been made to grow primitive eyes.

To truly fulfil the potential of mini-brains, however, neuroscientists want to make them bigger and more complex. Some are attempting to grow them with blood vessels. Others are fusing two organoids, each mimicking a different part of the brain. Should they succeed, their lab-grown brains could model development and disease in the real thing in greater detail than ever before, paving the way to new insights and treatments.

But as researchers seek to make mini-brains genuinely worthy of the name, they move ever closer to a crucial question: at what point will their creations approach sentience?

The key to developing organoids was the discovery of stem cells, which have greater ability to multiply and be manipulated in a dish than ordinary bodily cells. The field leapt forward with the development of "induced pluripotent stem cells", in 2006, when Japanese researchers showed that it is possible to take a sample of skin cells from an adult and genetically reprogram them into stem cells resembling those of an embryo just a few days after conception. With the right chemical cues, the cells could then be coaxed to mature into all manner of other tissue types, including brain cells or neurons.

Another dimension

The downside of growing neurons on a flat surface in a dish is that it is an artificial setting. In real life, cells exist in three dimensions, jostling up against each other and in constant communication. The key to creating a three-dimensional ball of cells is to inject stem cells into a small blob of gel, suspended in liquid and constantly jiggled to stop it from sinking to the floor of the dish. Lancaster was among the first to do this with human stem cells that were then nudged into becoming neural stem cells. She found that the cells multiplied and developed into different tissue types, until they formed a ball – or a cerebral organoid.

In 2013, Lancaster described how, after two months, her organoids had developed lobes of brain-like tissue containing dozens of different types of mature neurons and immature neural stem cells in separate layers, organised around fluid-filled cavities. "The beauty of organoids is that they generate this tissue architecture," says Lancaster.

The promise was clear: organoids offered a unique opportunity for neuroscientists to bypass the practical and ethical issues with using human embryonic tissue samples to study the brain. Many other labs rushed to join the field, experimenting with different methods and coaxing their organoids into replicating different parts of the brain.

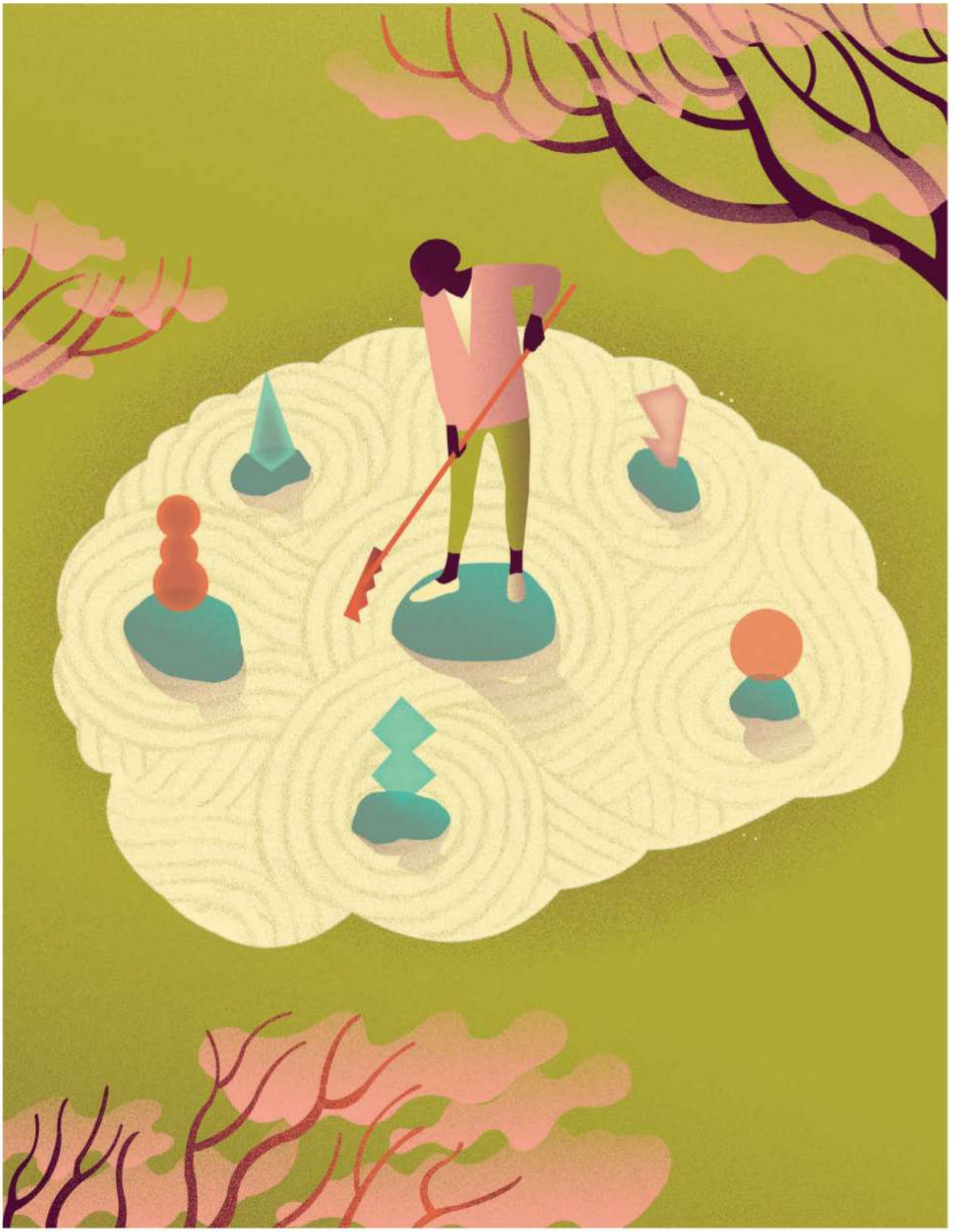
The balls of cells follow similar patterns to embryonic development, in terms of which cell layers form, which genes are active and which proteins are made. "One of the fascinating things is that there's a self-patterning process," says Fred Gage at the Salk Institute for Biological Studies in La Jolla, California. "You can just put [stem] cells in a dish under certain conditions and they'll form into structures that are quite remarkable."

Equally startling is that the mature neurons fire electrical signals, and different neurons sometimes show patterns of synchronous activity known as brainwaves, detectable by placing mini-brains on a grid of recording microelectrodes. They are similar in complexity to those of a fetus about a month before birth, according to Alysson Muotri at the University of California, San Diego, who has done some of the most attention-grabbing work on mini-brains.

Some groups have seen a further change in the organoids' behaviour around the nine-month mark. It is as if the cells register that if they were in a real-life brain, they would be born around that time, says Sergiu Pașca at Stanford University in California. "They start to resemble cells of the postnatal brain. They change their profile, the proteins they express." For instance, in newborn babies' brains, there is a change in the shape of a molecule called the NMDA receptor, involved in chemical signalling between neurons. This is also seen in Pașca's mini-brains after they have been nurtured for 8.5 to 10 months.

This isn't to suggest that mini-brains are the same as the brain of a real fetus or baby, not least because they cannot be made to grow beyond a few millimetres in diameter. But they have already produced some intriguing results.

Lancaster's main goal is to understand brain development and evolution. The two questions are linked because evolutionary change ›



NEIL WEBB

usually happens by modifying existing embryonic development pathways. "It's such a fundamental question that human beings have been wondering for millennia," says Lancaster. "What makes humans special as a species?" By comparing human mini-brains with those made from cells from chimpanzees and gorillas, last year her group found a genetic change that helps explain how human brains got so big. In the uterus, our neural stem cells spend longer at a stage where they are multiplying and so give rise to more brain cells.

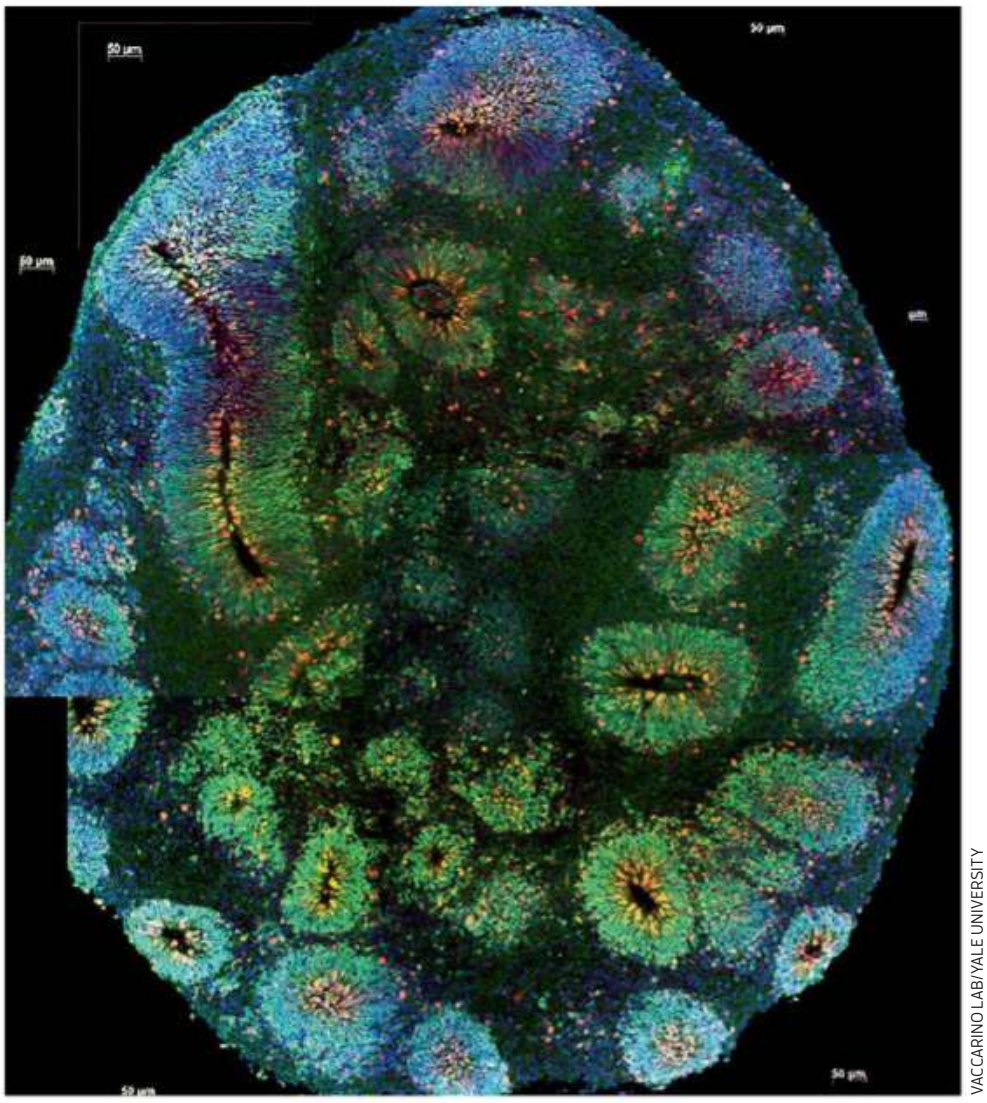
Other groups are creating mini-brains that mimic various medical conditions, made using skin cells taken from affected people. If genes play a major role in the condition, the organoid should share some features with the brains of those affected. Take motor neuron disease, which causes progressive paralysis, and frontotemporal dementia, an unusual form of dementia that tends to strike relatively early, in people's 50s. These two conditions may seem unrelated, but, in fact, they are often caused by mutations in the same small set of genes.

Those mutations usually diminish brain cells' ability to cope with damage to proteins and DNA that is linked to rising levels of a protein called poly(GA). And sure enough, the neurons of organoids made from cells taken from people with these conditions also showed these same features, including a rise in poly(GA), according to work published last year by Andras Lakatos at the University of Cambridge. That means he can watch how organoids develop the features of a disease over time. "You can see what's going wrong," he says.

Organoids are also being developed to help us understand autism, where people can have difficulties with communication and social skills and may have repetitive behaviours. Several groups using organoids made from cells from autistic people have uncovered hints about a key difference in their brains.

Flora Vaccarino at Yale University and her colleagues looked at the balance between "excitatory" brain cells, whose raised activity triggers the firing of downstream neurons, and their rarer "inhibitory" counterparts, which block firing in subsequent neurons. They found that organoid models of autistic brains contain more inhibitory neurons. It still isn't clear how this relates to features of autism, but Vaccarino suggests that the greater number of inhibitory neurons could affect how the fetal brain wires up. "They regulate early circuitry," she says.

Vaccarino adds that her findings show that



VACCARINO LAB/YALE UNIVERSITY

A human brain organoid under the microscope

"We can watch how organoids develop the features of a disease over time"

organoids can shed light on genetic brain conditions even when the mutations responsible are unknown. The families in her study have some members with profound autism and some without, but the genetic variants responsible – which seem to be different for each family – are still undetermined. Yet the elevated numbers of inhibitory neurons in all the organoids made from cells from autistic people could be traced to higher levels of a molecule called FOXG1. Presumably, many different autism genes act through FOXG1, which is now a prime target for further investigation.

These are important insights, demonstrating the power of organoids to study the brain in ways that would otherwise be impossible. But organoids are still an imperfect model of the human brain. The most obvious difference is that, for the moment, their growth stalls after a few months, when they are just a few millimetres wide.

The reason brain organoids don't keep growing is because they lack a blood supply to deliver oxygen and nutrients. Unlike natural

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tissue, organoids must rely on whatever seeps in passively from the nutrient liquid in their dish. And once they reach a certain size, that isn't enough. They stop growing and cells at their centre start to die. Vascularisation isn't only important for size, though. The growth of blood vessels also regulates neural development, cell migration and circuit formation during early brain development. Their absence, then, means organoids aren't as realistic as they could be, and that limits how much we can learn, says Lancaster. "I'm not sure that they're really what I would call healthy brain tissue." The problem is that it has proven extremely tricky to vascularise any lab-grown tissue, never mind brain tissue. Not that it has stopped people trying.

Gage's approach is to transplant a small, immature organoid into the brain of a mouse, which lets the mouse's blood vessels invade the human mini-brain. His team found that the human brain cells accepted ingrowing blood vessels and made connections with the mouse brain. The big drawback, as Gage acknowledges, is that you no longer have a completely human mini-brain.

At least two groups have managed to get human blood vessels growing in human mini-brains, although the work is still in its early stages. One group did this by first creating blood vessel organoids from immature stem cells, and then fusing these with brain organoids – the result was vascularised mini-brains that lasted for at least 50 days. Another group has added to some of the neurons a gene normally active in developing blood vessel cells, and made it switch on when the organoids were 18 days old. In effect, this made brain cells turn into blood vessel cells, and they self-organised into a network of blood vessels.

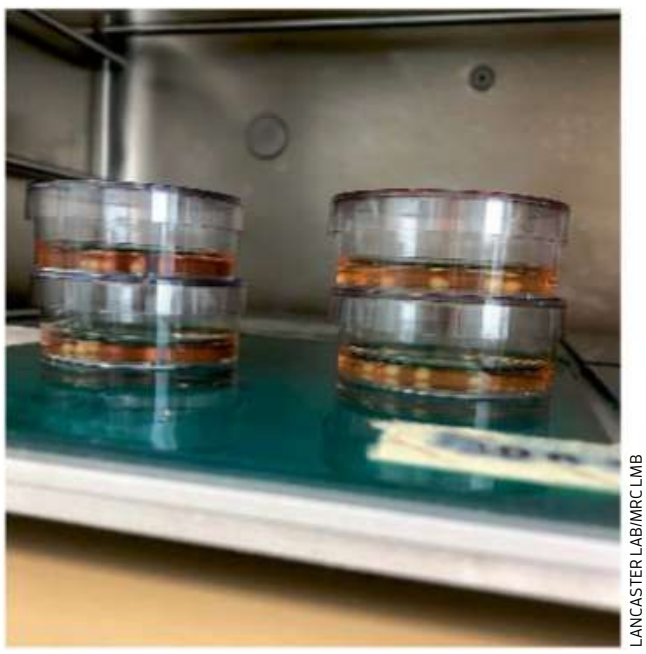
The resulting brain organoids seemed to have more mature neurons, although they were no bigger than ordinary organoids, says In-Hyun Park at Yale School of Medicine, who led the work. His tea m is now trying to encourage the structures to grow a lymphatic system, a network of tubes similar to capillaries that take away waste from tissues.

Muotri and his colleagues take a different approach. They grow mini-brains around fibres made from a material that dissolves if the dish is exposed to certain chemicals. After several weeks, the fibres are destroyed, leaving hollow channels inside the organoid. From that point, the organoid is kept in a chamber that gently pumps the nutrient fluid through the channels. Immature blood vessel stem cells are introduced and they stick to the walls, flatten out and become the walls of blood-vessel-like tubes, says Erin LaMontagne, also at the University of California, San Diego. The work hasn't been published yet, but she says that perfusing the organoids with the nutrient liquid changes them, leading to more mature synapses, the junctions between neurons.

Making connections

Others are exploring another route to greater complexity: to make several organoids that mimic different parts of the brain, then connect them to each other, making a larger structure known as an assembloid. Pașca, for example, has joined up a cortical organoid to a spinal cord organoid, which connects to a bundle of muscle fibres in a dish, in order to simulate the circuitry that controls movement in living animals. When the cortical organoid is stimulated, the muscle fibres twitch.

Assembloids are already shedding light on another key feature of fetal brain development, the migration of neurons. "It's almost a rule: neurons do not rest in the place they were born," says Pașca. "That migration is not just a movement. Very often, it involves maturation that's only triggered by migration." When Pașca's group merged a cortical organoid with an organoid representing a part of the brain called the subpallium, it triggered neurons from the latter to migrate into the former.



LANCASTER LAB/MRC LMB

Human brain organoids growing in nutrient solution

The other major deficit of mini-brains, as things stand, is that they lack sensory input from the environment, which is necessary for brain circuits to develop normally. Muotri has taken the first steps in trying to provide that for his mini-brains, by wirelessly connecting them to small, crab-like robots that move around the floor. "The stage where we are now is closing the feedback loop," he says.

The organoids sit on top of an array of electrodes that can both detect electrical impulses in the brain cells and feed information back. "The robot is communicating what it is seeing to the organoid and the organoid is reacting to that," says Muotri. While there are videos of the robots on YouTube, the group hasn't yet published the results of how the feedback loop affects the mini-brains.

It remains to be seen which of these methods will be the best for making bigger and better mini-brains. But assuming that one or more of them will succeed, at some point, researchers will potentially confront the opposite problem: how to make sure their creations don't become too lifelike. That is because they have to consider the possibility that their brain organoids could become sentient, and therefore capable of feeling pain.

Sure, they are nowhere near as complex as the human brain – but neither is the brain of a mouse, and there are strict laws on what kind of experiments may be done on mice, says Lancaster. The development of brainwaves in organoids, as shown by Muotri, don't amount to consciousness, but Muotri predicts that organoids will inevitably reach some kind of mouse-like level of sentience. "We're gonna get there," he says. "And then we'll have to deal with the consequences."

How would we know if organoids do approach the consciousness levels of a mouse? And if any do, would we be obliged to destroy them – or to keep them alive for as long as possible? Addressing such questions is going to be hard because we don't understand the scientific basis of consciousness. Ironically, mini-brains could help with that. But at this stage, no one knows quite what they will be able to teach us, says Gage. "We are just at the beginning." ▮

Clare Wilson is a medical reporter at *New Scientist*

PETE REYNOLDS

Going viral

Plagues often spark cultural revolutions. Understanding why can help us in a post-pandemic world, finds **Laura Spinney**

FIRST the pharaoh changed his name, from Amenhotep IV to Akhenaten. Then he decreed that a new capital should be built far away from the old one. And in this city, one god should be worshipped, forsaking all others: the sun god Aten.

Akhenaten's heresy didn't last long, ending with his death less than 20 years later. It was a blip in the 3000 years of cultural stability that characterises Ancient Egypt, but its enduring trace in art and thought places it among the most debated religious revolutions of all time. One common explanation is that Akhenaten was fed up with the powerful priests in the old capital of Thebes, who worshipped many gods. But what if he was actually fleeing an epidemic?

The idea isn't new, but it has enjoyed a revival since covid-19 arrived. Having lived through the worst pandemic in a century, many Egyptologists and archaeologists are looking back with fresh eyes. They have seen first-hand the social impact a pandemic can have – the exacerbation of inequality, rejection of authority, xenophobia and search for meaning – and realised that these probably aren't without precedent. "Communicable disease plays a cultural and economic role that is repeated through time, up to the present day," says Louise Hitchcock at the University of Melbourne, Australia.

Witnessing how tightly entwined social discord, viral ideas and real viruses are, Hitchcock and others are asking if this could explain major cultural shifts throughout history, from Akhenaten's time to the Black Death and 1918 flu. Could it even explain some of the ideological crosswinds that buffet us now, and that may shape the post-covid world?

The case for plague – meaning any infectious disease of epidemic proportions – in late Bronze Age Egypt is circumstantial for now. In 2012, US Egyptologist Arielle Kozloff suggested that there were already signs of it in the reign of Akhenaten's father, Amenhotep III. She pointed to an eight-year gap in the written record, and the fact that Amenhotep ordered hundreds more statues of the lion-headed goddess of healing, Sekhmet, than of any other god. He also moved palaces at one point, in a possible attempt at isolation.

In 2020, Jorrit Kelder at Leiden University in the Netherlands proposed that the same plague might have pushed Akhenaten to take more drastic action. Kelder had seen how frequently people felt let down by the governments they expected to protect them from covid-19. Akhenaten's reformation of Egyptian religion in the 14th century BC "may perhaps be seen as a pre-emptive move to highlight not his, but the traditional Gods' failure to protect Egypt", he wrote. However, Akhenaten's new city, Amarna, quickly became a critical hub in an international network of trade and diplomacy – "a byword for the first cosmopolitan age", says Kelder. So it might not have escaped the plague as its founder had hoped. And the same plague might have caused his death as well as those of his wife Nefertiti and three of their daughters.

> **"As infectious diseases increase, so do authoritarian attitudes"**

The mysterious disease might also have spread beyond Egypt, especially once people started deserting Amarna. Hitchcock wonders if it weakened a string of Mediterranean civilisations, leading to their demise at the hands of the Sea Peoples (a group that rampaged through the eastern Mediterranean) and to the end of the Bronze Age just over a century later. She and Kelder stress that they aren't Egyptologists – although both are archaeologists working on late Bronze Age Mediterranean civilisations – and their hypotheses are just that. Egyptologists, meanwhile, are divided over what happened at Amarna (see "A plague of Egypt?", page 40).

One person who isn't surprised that those who study ancient history are thinking this way is Joel Finkelstein, co-founder of the not-for-profit Network Contagion Research Institute (NCRI) in Lawrenceville, New Jersey. The NCRI tracks information trends across social media networks and correlates them with real-world events. Since the beginning of the covid-19 pandemic, across the political spectrum, the network has watched the rise of "essentially religious revolutionary groups that are breaking off from society in order to start something that will usher in a utopian era", says Finkelstein. Having built followings in the virtual realm, the activity of these groups has now spilled into the physical one.

Others too have observed people turning to religion in times of pestilence, even in today's increasingly secular age. Jeanet Bentzen at the University of Copenhagen, Denmark, found "a massive rise" in the intensity of prayer in the early months of the covid-19 pandemic, as measured by Google searches for prayer ›

texts across 107 countries. And in April 2020, the Pew Research Center in the US reported that a quarter of adults there said their faith had strengthened since covid-19 erupted.

What people look for in religion at such times is less clear, but there is a strong case that for many it is a stricter social order. Michele Gelfand at Stanford University in California has long argued that a society's norms tighten up in response to ecological threats such as disease, famine and natural hazards. These demand prosocial behaviour and large-scale cooperation, and one way to encourage such action is to invoke a vengeful god who punishes norm violators. In 2021, Gelfand's group reported that US states with high historical levels of ecological threat also have high levels of belief in punitive gods.

Religion isn't the only way to tighten a culture. In a study involving nearly 250,000 people in 47 countries, Leor Zmigrod at the University of Cambridge and her colleagues found that as infectious diseases become more prevalent, so do conservative, authoritarian attitudes – even after controlling for income, education and other factors. Intriguingly, the correlation only holds for diseases that are transmitted from person to person, rather than via an intermediate host or vector. This suggests that whatever is driving the authoritarian turn is profoundly social – to do with how we perceive others. Although the research predates covid-19, people's behaviour during the current pandemic has reinforced these findings. "This very social disease, this disease that can be acquired from other people, has led to a wave of authoritarianism around the world," says Zmigrod.

"What people are looking for is a new story to commit to"

In a worrying historical parallel, Kristian Blickle at the Federal Reserve Bank of New York found that, among German cities, the higher the death rate during the 1918 flu pandemic, the greater the share of the city's votes for the Nazi party in the early 1930s – again controlling for factors such as income and unemployment. "There is a real fear of chaos in [epidemic] settings, so it's this desire for tightness that I think predicts support for strict gods and governments," says Gelfand. And wherever people seek control, she adds, it seems to involve reinforcing group boundaries and a greater preference for one's in-group. Last year, Brian O'Shea at the University of Nottingham, UK, and his colleagues reported that the main factor driving this is aversion to germs in "outsiders" – whether they are foreigners or compatriots perceived as belonging to a different ethnic, religious or other subgroup.

We have seen this in the past two years, of course. For example, the NCRI has tracked the rise of the anti-government boogaloo movement, which includes white supremacists and neo-Nazis. Although it predates the pandemic, it really took off at the reopen rallies held across the US in spring 2020. Its followers, some of whom have since been charged with serious crimes, stood out with their Hawaiian shirts and Pepe the Frog badges, and online with apocalyptic memes including #DOTR for "day of the rope" and #RWDS for "right wing death squad". Covid-19

A plague of Egypt?

Ancient epidemics are very hard to detect because few infectious diseases leave traces on bones. Nevertheless, some archaeologists believe that a plague swept through Egypt in the mid-14th century BC, spurring a cultural revolution (see main story).

One clue comes from EA35, a tablet of baked clay belonging to a cache of diplomatic correspondence known as the "Amarna letters", on which the king of what is now Cyprus informs the pharaoh that a shipment of copper will be delayed due to sickness at its origin. Another is a collection of texts revealing that plague ravaged the mighty Hittite kingdom – in what is now Turkey – later that century, apparently brought by Egyptian prisoners of war.

From 2005, archaeologists excavating Amarna – the city built by the revolutionary Egyptian pharaoh Akhenaten – unearthed what looked like further evidence. Anna Stevens at the University of Cambridge, who leads the Amarna cemetery project, says that one cemetery in particular, North Tombs, seems to corroborate the plague idea. There, the dead show a narrow age profile – from 7 to 24 – and around 40 per cent of excavated burials contain more than one person, sometimes as many as seven. "It's pretty clear that they were dying close in time to one another," she says.

As other cemeteries were excavated, however, they revealed a more standard age profile and individual burials. An epidemic can't be ruled out, says Stevens, but in light of evidence that life for Akhenaten's workers was gruelling and their immune systems less than robust, her group now thinks that constantly present diseases are sufficient to explain what they see.

Others remain open to the epidemic hypothesis, however. Nicole Smith-Guzmán at the Smithsonian Tropical Research Institute in Panama City, who has worked at Amarna, believes its inhabitants experienced high levels of malaria – so high that when the city fell, they may have triggered epidemics of it further afield.

SCIENCE HISTORY IMAGES/ALAMY

A likeness of revolutionary pharaoh Akhenaten and his wife Nefertiti

Eva Panagiotakopulu at the University of Edinburgh, UK, has found another smoking gun: excellently preserved fleas in Amarna's workmen's village. In an area where bubonic plague might already have been endemic, she says, the combination of a large concentration of people, the run-down nature of the settlement and trade on the Nile, made Amarna a "prime situation where [bubonic] plague could spread". It is a theory she intends to go back and test.

has also brought a wave of xenophobic attacks on people of Asian origin and a deluge of anti-Semitic disinformation online. Anti-Semitism is an ancient trope in times of contagion, says Finkelstein, going back to the Israelites' exodus from Egypt following a spate of plagues.

Control and exclusion aren't the only possible reasons for the coincidence of pandemics and social upheaval, though. Nina Witoszek at the University of Oslo, Norway, and Mads Larsen at the University of California, Los Angeles, study the role of narrative in cultural evolution, and they believe that what people are looking for is a new story. "When we feel threatened, we have anxiety," says Larsen. "To ameliorate that anxiety, humans need a story to commit to."

A plague challenges the "master narrative" told by the spiritual or secular leaders and allows new stories to emerge that explain where things went wrong, and how to put them right. In an earlier parallel of boogaloo, the mid-14th century saw the rise of a southern European movement called the Flagellants, which had existed at the margins of society for a century, but became far more influential during the Black Death. When people asked why a benevolent god would inflict this horrible disease on them, the Flagellants responded that their faith wasn't strong enough. They roamed from town to town, whipping themselves, harassing priests and murdering Jews. Theirs wasn't the only story vying for acceptance at that time. There were conspiratorial explanations for the scourge too, says Witoszek, and "all kinds of wizardry".

Michael Muthukrishna at the London School of Economics, who studies cultural evolution, has a Darwinian way of looking at this. Shocks such as epidemics throw up constellations of ideological "mutations", he says. Then, the cultural equivalent of natural selection goes to work, weeding out the less well adapted mutations in the population while the others become more established.

How might that work in practice? Germs and ideas both travel through human social networks, says sociologist and physician Nicholas Christakis at Yale University. These networks have evolved to strike an optimal balance between the advantages and disadvantages of being exposed to other people – principally, learning from them versus catching dangerous germs or ideas. "The spread of germs is the price we pay for the spread of ideas," he says. As Christakis and his colleagues showed using information about Harvard students gathered during the 2009 H1N1 flu pandemic, ideas can travel faster than germs and facilitate or block their spread. These are dynamic, competitive processes, shaped by many factors. For instance, the idea of rejecting flu vaccines might spread and persist if promulgated by a charismatic influencer or if lockdown reduces people's exposure to other ideas. But it becomes self-limiting if people die, weakening the information network.

There is an unsettling link between death rates during the 1918 flu pandemic and the rise of the Nazi party

HULTON ARCHIVE/GETTY IMAGES

Changing narratives

The Flagellants remained a thorn in the side of the Catholic church for decades. Eventually, says Witoszek, the church reimposed its authority after subjecting itself to "a cleansing operation", addressing its own failings to win back the faithful. In other words, to remain dominant, the master narrative bent towards its challengers. There seems to have been no such bending towards Akhenaten's disruptive ideas: later pharaohs were largely successful in erasing his memory. However, some Egyptologists suggest that his cultural experiment marked the beginning of the decline of the all-powerful pharaoh, and that it laid the ground for Hebrew monotheism.

"We have a lot of clear evidence that major transformative change comes on the heels of big societal disasters – but it's not automatic," says Daniel Hoyer, project manager of Seshat, a repository for global historical data. For change to happen, the society must take advantage of the disruption by correcting course, he says. If it doesn't, it risks being even more vulnerable to the next shock.

"Few if any society so far has collapsed solely as a result of an epidemic," says Kelder. But it is true that the same forces that make societies vulnerable to contagion – widening inequality, population explosion, globalisation – also make them susceptible to revolutionary ideas, and they ignore these ideas at their peril. So, we should expect today's pandemic to bring change, says Hitchcock. "History suggests that... the post-covid normal is unlikely to look much like the old normal." ▮

Laura Spinney is a writer based in Paris, France, and author of *Pale Rider: The Spanish flu of 1918 and how it changed the world*

"Titan is like a firecracker waiting for someone to light a match"

Scott Bolton has spent two decades heading missions to Jupiter, Saturn and their exotic moons, such as Titan. He tells Joshua Howgego about the amazing insights and fresh puzzles that have been revealed

SOME 750 million kilometres from here, a huge ball banded in orange and white hangs in the blackness of space: Jupiter. Travel about the same distance again and you hit the ringed planet Saturn. Of all the planets, these two gas giants dominate our solar system – and over the past two decades, they have also worked their way into our collective imaginations as spacecraft sent to explore them and their moons have returned their findings. We have seen a hexagonal storm dancing around Jupiter's north pole, methane rain on one of Saturn's moons, Titan, and discovered liquid water spewing from geysers on the surface of another of Saturn's moons, Enceladus.

Many people have worked on these discoveries, but Scott Bolton at the Southwest Research Institute's Space Science & Engineering Division in San Antonio, Texas, has been a central figure. After overseeing the Galileo mission to Jupiter between 1989 and 2003, he was the lead scientist on the Cassini mission that studied Saturn for 13 years until 2017 and is now at the helm of the Juno mission, which has been orbiting Jupiter since 2016. *New Scientist* spoke to him about his two decades of exploring the gas giants and what we still have to learn.

NABIL NEZZAR

Joshua Howgego: You were a key scientist on the Cassini mission to Saturn and it turned out to be an iconic piece of space exploration. Take us back to the late 90s when it began.
Scott Bolton: Cassini was a follow on to Voyager [a mission preceding Galileo], which had gone by Jupiter and Saturn. There were two Voyager probes and they were both capable of going out to the far reaches of the solar system. But Titan, a moon of Saturn, was deemed so important to study that the path of one of the probes was tweaked, sacrificing the prospect of it going on to Uranus and Neptune just so it could get a close view of Titan. At that time, it was thought that Titan was like a prebiotic Earth. But when Voyager got close, we were only able to see Titan's atmospheric haze, which was so thick you could hardly see through it. Nevertheless, what Voyager found only increased interest. Cassini was designed to follow that up, to study Saturn and all its moons, including a major effort to study Titan both with a NASA-built orbiter and a probe that was provided by the European Space Agency (ESA).

What did the Cassini mission achieve?
It was a flagship mission [the most expensive and ambitious of NASA's mission classes], so it dealt with the full breadth of scientific targets that are associated with a giant planet. It had new radar instruments to see through the haze and map out the surface of Titan, which was a very high priority because of its possible habitability and features like lakes – liquid methane lakes, that is. I used to joke that Titan was a giant firecracker waiting for somebody to light a match.

Of course, there was also the study of Saturn and its rings. Initially, we kept Cassini away and didn't go through the rings because it was dangerous. But it had to go through the ring plane sometimes and that was a little iffy. Then there was the smorgasbord of satellites and moons around Saturn.

Were there any that were particularly interesting?
One of the most important was Enceladus. This little moon stunned Cassini scientists with the discovery of a global ocean under its icy shell, active geysers that spew 200 kilometres above the surface and signs of hydrothermal activity. We had another special instrument on Cassini, a mass spectrometer, and using that we could really look at the composition and try to understand what was going on in the geyser plumes. Cassini's mass spectrometry measurements at Enceladus were particularly exciting because they identified some of the ›

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elements for habitability (or for life to develop): liquid water, carbon dioxide and organic materials alongside available energy.

What do you think about Cassini, looking back, and how did it compare with the Galileo mission to Jupiter, which came before?
It lasted a long time and it definitely represented a great accomplishment for both NASA and ESA. Galileo was also a great mission. Unfortunately, it had some elements that didn't work. It was disadvantaged by the fact that its main antenna didn't completely open and its old-fashioned tape recorder, which was used for storing scientific data, also had problems. Cassini didn't experience major failures – nearly everything worked. The amazing images that it could return, plus all of its discoveries regarding Saturn and its rings and moons, were inspirational. I loved working on Cassini.

What gave you the idea for the Juno mission to Jupiter?
The idea of a polar orbiter around Jupiter goes way back. But when we were going past Jupiter with Cassini on the way to Saturn, I was thinking about calibrating our instruments and what we could learn about Jupiter. Two colleagues of mine, Toby Owen and Daniel Gautier, came to me and asked if we could use the radar instrument to measure Jupiter's deep atmospheric temperature. They told me that if we could make this measurement it would help us understand how Jupiter formed. I thought that sounded pretty profound.

I went home and thought about it some more, and then said I don't think I can do it with Cassini. But if we get a spacecraft with this other kind of instrument – which didn't really exist at the time – and you put it into this kind of an orbit, I think we could. And they said: that's the basis of a whole mission.

That mission eventually became Juno. Where have we got to on its central mission, finding out how Jupiter formed?
There were a couple of measurements that were important for us. One was: what is the core of heavy elements – those heavier than helium – inside Jupiter like? Was there a kind of solid core, or no core at all? If Jupiter forms like the sun – a cloud of gas and dust that collapses in on itself – there might not be a core of heavy elements. If Jupiter formed more like a planet – you have rocky, icy things banging into each other and gluing together into a lump the size of Earth, say – then you expect to see that rocky core still inside Jupiter today.

> "We realised that neither of our original ideas of how Jupiter formed really work"

An illustration of NASA's Juno spacecraft passing above Jupiter's south pole

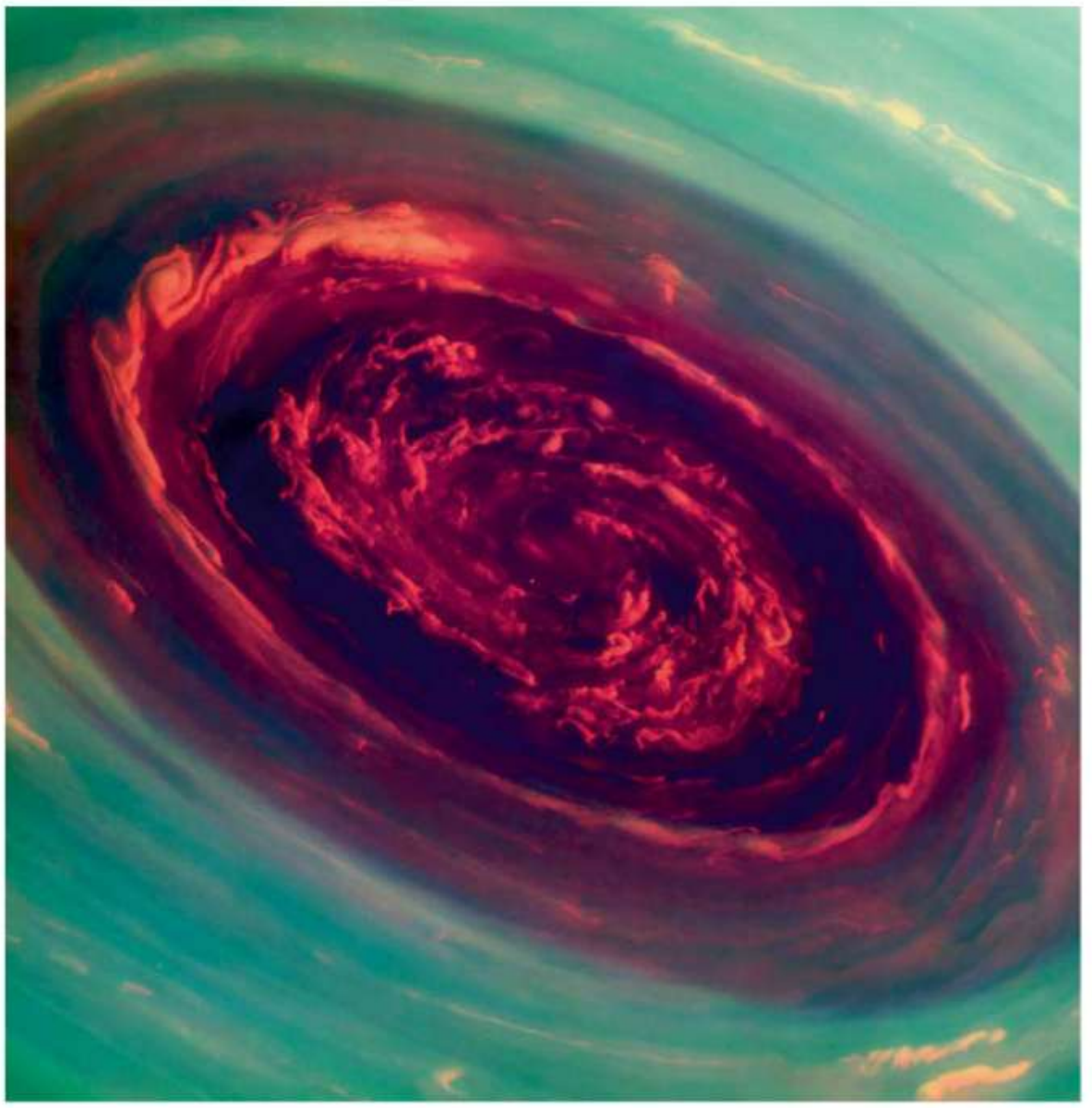
NASA/JPL-CALTECH

When Juno got there and made those measurements it was a humbling experience because neither of those scenarios turned out to be right. Instead, we saw a dilute, fuzzy core that was quite large. There may be a compact core inside, and now our mission has been extended, hopefully, we'll be able to determine that. But we have realised that neither of the original theories really work. To a scientist, this can be disappointing, but it is also exciting. We discovered something that we didn't expect, which is ultimately great. Theorists are now working to explain how to make a Jupiter with a core that's consistent with Juno's data. But there is no answer yet.

The other part of the mission was to find out what Jupiter is made of. Is that making any more sense?
There has been a long assumption that if we could drop below Jupiter's cloud base, below the weather, then all the gas would be well mixed and we would be able to get an accurate sense of the overall composition of Jupiter. That was the goal for the Galileo probe: measuring the global abundances of heavy elements in Jupiter. A key question was the oxygen or water abundance. If we knew that, we could plug it into models with the other heavy elements to understand how we could have got a Jupiter with the measured composition.

Unfortunately, the Galileo probe measurements were puzzling and scientists believed they were not representative of a global Jupiter; that we were unlucky in sampling a spot that was unusually warm and dry – sort of the Sahara desert of Jupiter.

So Juno was created to evaluate the atmosphere at many locations using its Microwave Radiometer instrument that can look far into the atmosphere, much deeper than a probe could reach. With Juno, way below the clouds, we saw that the ammonia and water abundances are still varying. This was a complete surprise as scientists believed that below the weather layer, where water and



NASA/JPL-CALTECH/SSI

False-colour image of the storm at Saturn's north pole, captured by NASA's Cassini spacecraft

ammonia condense, the atmosphere would be well mixed. But this isn't true, and nobody knows why or how that could be. It is very hard to get a global average – and even if you do, you have to wonder whether it represents a global average that goes all the way down to the middle of Jupiter.

What is the best explanation for this so far?
There was a paper published in 2021 by Tristan Guillot at the Côte d'Azur Observatory in Nice, France, and his colleagues. They hypothesised that maybe there is something like mushy hail – they called it "mushballs" – that were formed in the storms of Jupiter high up in its atmosphere. And so these mushballs, which are about the size of a baseball, would trap either water, ice or ammonia that could be carried down as a liquid below the condensation level before it evaporated, leaving it unevenly distributed.

One of Juno's latest undertakings was flying past Ganymede, Jupiter's largest moon. Tell us about that.
In June 2021, Juno finished its primary mission, but since it has now been extended, we didn't have to dispose of the spacecraft. Instead, we were able to modify the orbit to move closer to Jupiter's largest moons [Io, Callisto, Europa and Ganymede]. The first was Ganymede. We flew by at a distance of about 1000 kilometres and did a full sweep of satellite science.

For instance, we have this microwave instrument that observes in six different frequencies. Each frequency sees into the ice that covers the moon at a different depth. What we are trying to do is understand how that ice varies – how thick it is and what it's like. Ganymede is covered with different terrain types that we already knew about: dark, bright and middling stuff, and even linear-looking features that suggest tectonic activity. I think what's equally exciting is that we are going to get the same kind of map of Europa in a few months and its ice is very different to Ganymede's. I'm not sure we'll fully understand the Ganymede data until we see the same data on another body. Comparative studies like this are probably the most important tool of science and we're going to get that – it is really exciting.

Will all these observations lay a clearer path for JUICE and Europa Clipper, the other missions set to explore the Jupiter system?
Yes, both of those missions are being informed by Juno. Up until now, we had never been to the places that JUICE and Europa Clipper are going to go through, but as we go by the moons, we're taking measurements of the land on their surfaces, and we'll update our models of the radiation in the area, which is something that we all fear because it can fry spacecraft. On top of that, we're getting the first close up views of the satellites for many, many years, which helps inform future missions too.

Your work has been focused on Jupiter and Saturn. But there are other less well-explored planets in the solar system too. Where do you think we should go next?
Well, before two Venus missions were announced recently, I was one of those who felt quite strongly that Venus had been left out. Maybe we should have more Venus missions, some would argue, and I'm not against it – Venus is a very important target.

I think the ice giants of Neptune and Uranus represent a good next step as well. The big question is, how fast can you get there, because it takes a long time to develop the mission and get it approved, and then it takes a long time to travel out there. In the latest decadal survey [where once each decade NASA and its partners ask the National Research Council to prioritise future research areas, observations and notional missions], the Uranus mission was the number one flagship recommendation, but it also recognised that, given NASA's budget, it might not be possible to start that mission in the next decade.

I think one of the nice things Juno has shown is that something that you thought you needed a flagship mission for might be possible in a New Frontiers Program, which is intrinsically faster and less expensive. Juno's extended mission is demonstrating that we can not only study Uranus or Neptune with a Juno-like spacecraft, but you could actually do a good job on the satellites as well. I think that gives us hope that maybe another ice giant mission doesn't have to wait 20 years. ▮

Joshua Howgego is a feature editor at *New Scientist*

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Science of gardening

The forecast is chilli

Chilli plants can thrive in summer and survive the winter even in temperate climes, says the heat-loving **Clare Wilson**

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

A packet of chilli seeds
A propagator or a small plant pot and plastic bag
Larger pots
A cane for support
A sunny spot indoors or a greenhouse

Science of gardening appears every four weeks

Next week

Science with children

CHILLI plants hail from warmer parts of South America. As a result, they aren't natural candidates for growing in temperate countries like the UK, unless you have a greenhouse. But they also do well in pots, so if you have a suitable spot by a window to nurture them indoors, you can produce a good crop of chilli peppers.

The chilli is such a valuable culinary addition because it contains a chemical called capsaicin that binds to heat receptors called TRPV1 on our tongues, triggering sensations ranging from tingling to agony, depending on the concentration. The discoverer of this process won a share of the 2021 Nobel prize for physiology or medicine.

The reason for such chemical warfare is unclear. One idea is that it deters munching of the fruit by mammals. Leaving them available to be eaten by birds – which have a slightly different form of the heat receptors and so are impervious to their effects – allows the seeds to be spread further. But capsaicin might also help the plants by blocking the growth of a fungus prone to infecting the fruit if they are eaten by insects. Either way, some of us humans relish the kick chillies bring to food.

To grow your own, germinate some seeds in late winter or early spring in a heated propagator or on a sunny windowsill in pots covered with plastic bags, to create a miniature greenhouse.

As the seedlings grow, they no longer need a cover and can be moved to progressively larger pots. In warmer parts of the UK, you might get away with putting the plants outside in sunny weather, once they are a good size, although this may reduce the crop.

GAP PHOTOS/RACHEL WARNE

The flowers should be self-pollinating, but to be safe, gently shake them to help the pollen reach the stigma in the centre. Once the fruits form, some growers advocate a range of strategies to get hotter chillies, including tearing off a few leaves to mimic munching by herbivores – this is supposed to make the plants produce more capsaicin in defence. Or just buy varieties that are naturally hotter, such as Prairie Fire – there is a huge range.

This year, I will be trying something new: keeping a chilli plant alive over winter. In contrast to the plant's summer needs, you are now aiming for a cool-enough temperature range, of 5°C to 12°C. Depending on the weather, this could be somewhere such as a shed, garage or a front porch.

Before overwintering, harvest any remaining fruit, then cut off all branches and trim the top off the main stem so you are left with just 15 centimetres. For convenience, place in a smaller pot, trimming the root ball if necessary, and store. Water only when the compost is getting dry.

In late winter or early spring, awaken the plant by moving it to a warm and sunny spot. This will give you a head start on a good crop of fruit the next summer. ▮

These articles are posted each week at newscientist.com/maker

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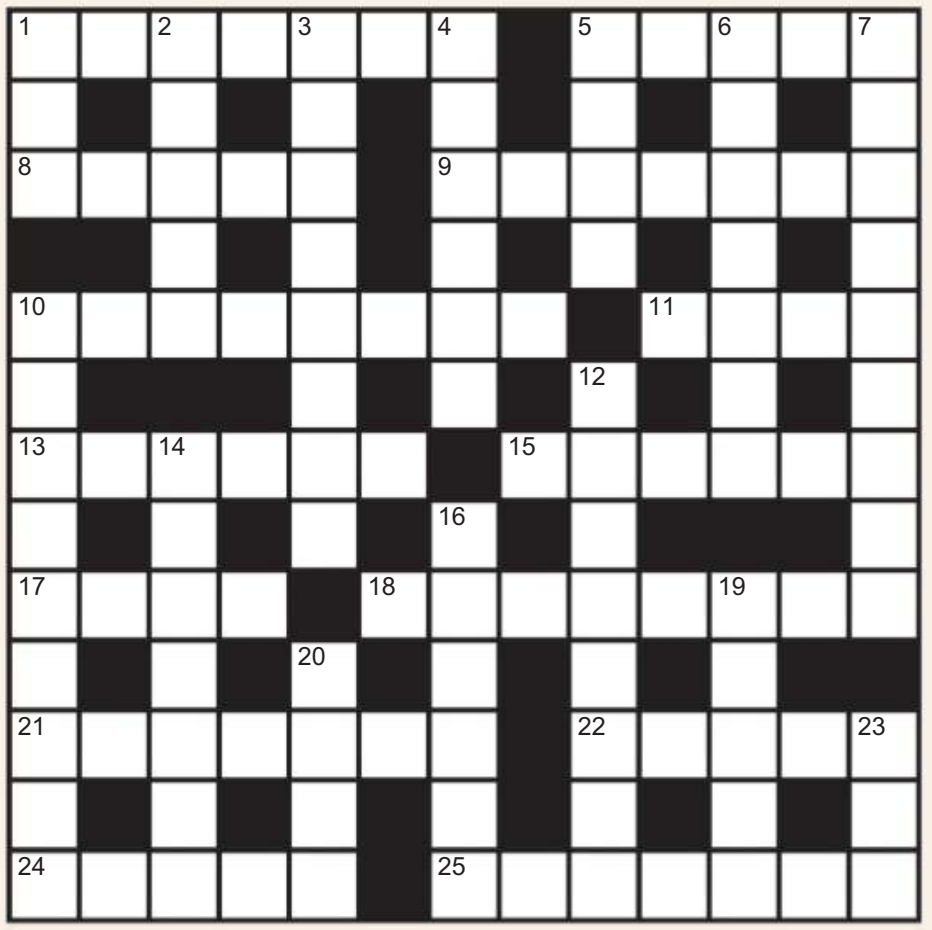
Cryptic crossword #88 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Time to abandon science relating to NASA growing things amid stones (7)
5 Trig symbol article by prof's helper (5)
8 Try extremely elegant washroom fixture (5)
9 Judge circus routine after performer's last bend (7)
10 New embargo against Tetley's primary tea flavouring (8)
11 Unyielding tree mass (4)
13 Vocally identify flatfish (6)
15 Insect flying around throne (6)
17 Blood factor seen with each ostrich's relative (4)
18 For example, king and bishop scheme deviously, taking in second knight (8)
21 Debtor's note includes a planetarium's display? Imagine (1,3,3)
22 More mature shrub (5)
24 Follow us north, heading west in case of earthquake (5)
25 Add water to beat dry heat (7)

DOWN

1 Buff precious stone lacking finish (3)
2 Programmer redesigned decor (5)
3 Don't bore portal (8)
4 Raise concern about a medicinal herb (6)
5 Note very loud quarrel (4)
6 Joy recalled story on sulphate, for one (7)
7 Gold and red on back of iron robot (9)
10 Dual snare I turned over in snake attack (9)
12 Cask agriculturalist initially buried in pigsty? (8)
14 Measure of pressure maintained by leaderless army stations for sterile state (7)
16 Bird that's half-hidden by marsh plant (6)
19 Paint and pastels, say, used to make biome diagram (5)
20 Force unit colour to include navy (4)
23 For the audience, rank sushi-topping morsels (3)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #161

1 The boundary between the sun's atmosphere and the beginning of the solar wind in space is known as what?

2 What name is given to a hypothetical particle made entirely of gluons, with no quarks?

3 What kind of fruit comes from trees of the species *Diospyros kaki*?

4 How many elements make up group 1 of the periodic table?

5 In genetics, what does CRISPR stand for?

Answers on page 55

Puzzle

set by Rob Eastaway

#177 Monkeying around

Scientists have been studying two rare monkey species in a forest.

In one part of the forest live the *Equalis* monkeys, which are split 50-50 between males and females. In another part of the forest are the *Fraternis* monkeys, of which exactly two-thirds are male – the evolutionary aspect of this isn't yet known.

Both species are monogamous, with families coming in all shapes and sizes. Some parents stop at one offspring, but there are others with 10 or more, so some monkeys have lots of brothers, while others have none at all. The sex of any infant is independent of others in their family.

Among *Equalis* monkeys, which should expect to have more brothers, the males or the females? And how about *Fraternis* monkeys?

Solution next week

Different strokes

I am a casual swimmer who does a steady breaststroke in the pool. I am often overtaken by people doing front crawl, but who is actually swimming the more efficient stroke?

***@laurafae_**, via Twitter*
As a competitive swimmer for 10 years, front crawl is the most efficient stroke when done correctly due to having the least active drag. However, if the technique isn't correct, it can be one of the hardest.

Chris Boynieson
via Facebook
In terms of energy expended, front crawl is more efficient for a skilled swimmer. Breaststroke uses the big leg muscles, and you can spend half the stroke in a glide, so it feels much easier.

***@newnhamengineer**, via Twitter*
It is so difficult to get the breathing exactly right for the front crawl, which makes it more exhausting than breaststroke. While breaststroke is less efficient, it is more forgiving, manageable and practical.

"While breaststroke is less efficient, it is hard to get the breathing exactly right for front crawl, which can make it more exhausting"

***@welsh_shaun**, via Twitter*
There is a reason "freestyle" competitors all do front crawl. Technically, they could choose any stroke for these races.

***@TomorrowMaking**, via Twitter*
I write as someone who has been a competitive swimmer, a lifeguard and is now a leisure swimmer. If I wanted to reach someone quickly, the most efficient stroke is front crawl. If I want to swim indefinitely with no speed concern, then breaststroke is.

***@the_biologian**, via Twitter*
Faster doesn't equal more efficient. You can drive your car slower and get better miles per gallon. Going fast covers distance quickly, but will not get you as far per unit of energy expended.

Simon Dales
via email
The front crawl is much more efficient than breaststroke.

Water is very dense, so swimmers are fighting drag all the time and must minimise the area of any body part in relation to the direction of movement. Ideally, you only move your limbs aft (rearwards) in the water, but with breaststroke, you have to push your arms and legs forwards and sideways, which creates a lot of drag. With freestyle, the arms only move backwards in the water, and are then moved forwards "for free" in the air.

Efficient swimmers spend most of their time long and flat in the water, like a telegraph pole.

In open-water races, swimmers tuck in behind each other to reduce drag. A breaststroker's wake is too diffuse and turbulent to be of much use for this. Behind a freestyler, it is smooth and tight. The swimmers tuck tight to each other and synchronise their arms.

Mike Follows
Sutton Coldfield, West Midlands, UK
Front crawl allows you to travel further or faster, or both, using the same amount of energy.

Drag increases with the square of a swimmer's speed. This favours a stroke with a more constant speed as a big penalty is paid for bursts of speed. The front crawl produces a more even speed, partly because the application of power is spread out over two arm pulls for every double-arm pull in the breaststroke.

In front crawl, maybe 90 per cent of the power comes from the arms and 10 per cent from the legs. For breaststroke (and butterfly), the arms and legs share the effort equally. Arms are better designed to pull the water.

The breaststroke allows swimmers to keep their heads above water at all times, but competitive swimmers will spend most of their time submerged, as they experience less drag.

If you look at a swimmer head-on, you will see that the best front crawlers spend most of their time with their shoulders and hips nearly perpendicular to the water surface. They achieve this by rolling their bodies through 180 degrees between each arm pull. This makes their "hull" narrower and means they come up against less drag. There seems to be less scope for breaststroke swimmers to reduce their drag.

But it might be consoling for breaststroke swimmers covering the same distance as a front crawl swimmer to know they will burn more calories during the session.

ROB ALLWRIGHT

A glitch in the matrix? What made these contrails end so abruptly?

This week's new questions

Broken clouds **The image (above) is of the morning sky over London one hot day in June. Why do the contrails end so evenly and abruptly? *Rob Allwright,** *Bushey, Hertfordshire, UK*

Hole number **My microwave meal says remove sleeve and pierce film. What is the optimal number of holes I should make? *Bob Yelland,** *Alton, Hampshire, UK*

Peas in pod

Peas are in the dark inside a pod, so can't use their chlorophyll for photosynthesis. In which case, why are they green?

Jo Murphy
Waikanae, New Zealand
Peas aren't "in the dark" because light penetrates almost all vegetation during daylight hours.

Roy Smith
Burntwood, Staffordshire, UK
Pea pods are translucent even

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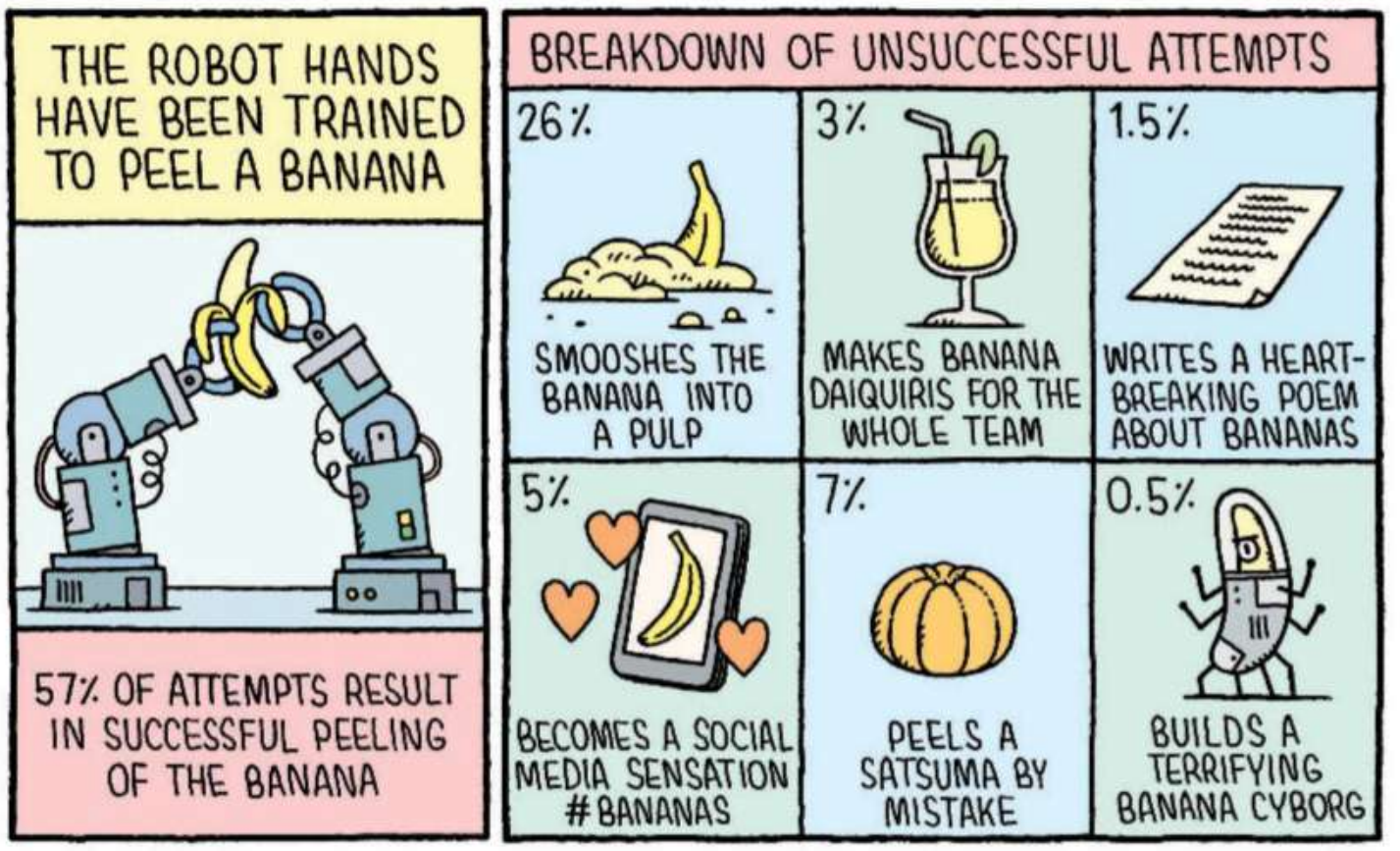
Tom Gauld
for New Scientist



when mature. I often look through the pods of the peas I grow, to see when they are ready to harvest. Even when mature, some light gets through the pod wall.

Think about shrubs in a forest – they get much less light than the treetops, but still enough to photosynthesise and even their lowest leaves are green. Likewise for peas in a pod.

Peter Jackman
Llandysul, Ceredigion, UK

Pea seeds naturally appear in a variety of colours from shades of yellow to dark purples, but it is the vibrant green pea that has been exploited widely for food and considered desirable. Selective breeding has been used to achieve this desired visual appearance.

Chlorophyll is broken down by proteins encoded by so-called stay-green genes, and the decline of chlorophyll levels causes yellowing of the peas.

Many plants that we eat have been selected for mutations in these genes, which thus cause retention of greenness.

"Pea seeds are naturally a variety of colours, but it is the vibrant green pea that has been widely exploited for food"

Magnetic weather

Does Earth's magnetic field affect the weather? (continued)

Jim Hone
University of Canberra, Australia

I read with interest the earlier attempt to answer this question (28 May), which suggested there was probably no link. However, there is some recent evidence that Earth's magnetic field may affect the weather.

A reversal of the magnetic field about 42,000 years ago, known as the Laschamps Excursion, occurred around the same time as substantial changes in the weather and changes in biodiversity in parts of the world, including the Pacific region. For example, megafauna extinctions peaked in Australia around this time.

This was outlined in a 2021 paper in the journal *Science* entitled "A global environmental crisis 42,000 years ago". This analysed ancient kauri trees preserved in northern New Zealand wetlands to reconstruct atmospheric carbon levels at that time. The researchers dubbed this crisis the "Adams Event" after the writer Douglas Adams because of the number 42, which is central to the plots of some of his books.

Casey Brown
Clyde, North Carolina, US

Reports in *New Scientist* from the 1980s addressed this issue, based on research by Goesta Wollin, a climate scientist at Columbia University, New York (I live in his former house).

These articles outline Wollin's findings of a link between the rate of change in Earth's magnetic field and sea surface temperatures, for instance, and his claim that winter blizzards can be predicted two days ahead from magnetic changes. ▮

Answers

Quick quiz #161 *Answers*

1 The Alfvén critical surface
2 A glueball
3 Persimmons
4 Seven
5 Clustered regularly interspaced short palindromic repeats

Quick crossword #112 *Answers*

ACROSS 6 Shutter, **7** *The Blob*, **9** Uvula, **10** Albatross, **11** Viscera, **13** Annual, **15** Mushroom cloud, **19** Raceme, **20** Aconite, **23** *Backdraft*, **24** Cubit, **26** Sedated, **27** Science

DOWN 1 Kudu, **2** Ethane, **3** Ursa Major, **4** Fentanyl, **5** Altocumuli, **6** Scurvy, **7** Tube, **8** Basalt, **12** *Source Code*, **14** Smear test, **16** Humidity, **17** Erebus, **18** Pestle, **21** Orchid, **22** Yard, **25** Bing

#176 Ant-i-clockwise *Solution*

The minute hand rotates 6 degrees per minute. So, during the 15 minutes of the ant's anticlockwise walk, the hand moves 15 x 6 degrees = 90. In that time, the ant travels around 360 degrees - 90 degrees = 270 degrees of the clock face, which is 18 degrees per minute, or three times the speed of the minute hand. In the first, clockwise stage of the ant's journey, the ant must therefore move through 300 degrees (the angle from 2 o'clock to 12 o'clock) + the angle (x) rotated by the minute hand. The ant travels at three times the speed of the minute hand, so 300 + x = 3x; x = 150 degrees, which takes the ant 25 minutes. The total journey takes 25 minutes (stage 1) plus 15 minutes (stage 2), so it stops walking at 2.40.

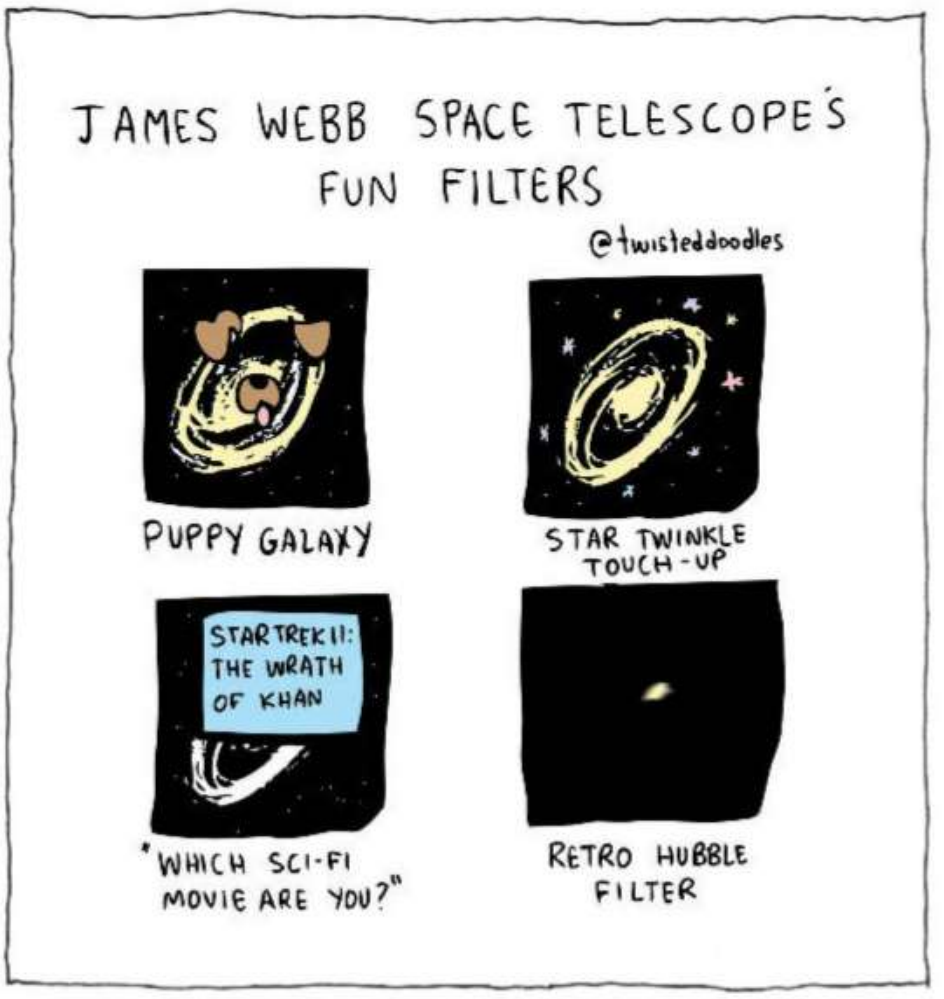
The dogs of war

Even the stationery cupboard, so well insulated from the outside world, now resounds to the yapping of shiba inus. Cartoon versions of these goofy-looking dogs, sporting tracksuits and fatigues in trademark Volodymyr Zelenskyy chic, are popping up across social media in response to Russian disinformation about the Ukraine invasion. No sooner do you post a pro-Vladimir Putin line, than tens of thousands of GIFs and JPEGs appear in reply, showing the dogs blowing up Russian fuel depots and firing anti-tank weapons.

Behind the dogs lurks NAFO, the North Atlantic Fella Organization. Former US Marine @IamtheWarax says many of the Fellas are military personnel with time on their hands, and that Russian officials who used to dedicate their days to spreading disinformation are now having to fend off "up to 100,000 soldiers who are just doing soldier shit".

Motherboard reports that the efforts have a charitable element, too: there are T-shirts for sale, you can adopt avatars and there is a chat server where the mutts arrange charity events, debunk Russian propaganda and share fact-checked news of the conflict.

Twisteddoodles *for New Scientist*



Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT
Consideration of items sent in the post will be delayed

Social security

Now the stationery cupboard is tidy, Feedback has been making tentative efforts to rejoin society. Oh, but it is difficult. We have an especial horror of reconnecting with people out of the blue. What will they say? What will they do? Will they remember that evening? Have they forgiven us? Do we owe them money? On and on like this. According to an encouraging new paper in the *Journal of Personality and Social Psychology*, such doubts are common – and quite unjustified.

Peggy Liu at the University of Pittsburgh and her colleagues have been using questionnaires and field experiments among college students to see how well people respond to being contacted by old acquaintances. Those doing the reaching out consistently underestimated how graciously and positively their messages would be received. We are also quite useless at asking each other for favours, says the study. We worry about what the favour will cost our friends, while forgetting how rotten they would feel if they refused to help.

The paper ends: "Our work provides robust evidence and an encouraging green light to go ahead and surprise someone by reaching out." Excited and enthused, and in a spirit of free and open experiment, Feedback has written to Liu asking for money.

Pre-worn pendants

These tidings of good cheer remind us that Christmas will soon (ish) be upon us. To show willing, Feedback has been considering what gifts to recommend to our readers this year.

How about a 8200-year-old bone pendant from a burial site in Russia? Kristiina Mannermaa at the University of Helsinki in Finland and her colleagues have been investigating what species pendants from the cemetery were made from – and were disconcerted to find that a few were fashioned from human femurs. Feedback feels the explanation for this doesn't have to be dark though. Maybe this was just the Stone Age equivalent of carrying a bit of your grandma's hair around in a locket.

Cold case

And who wouldn't be thrilled to receive an antique vampire-slayer kit? The one recently under the hammer at Hansons Auctioneers went for £16,900 – six times its reserve price – as bidders piled in from all over the world. Is there something in the air? Can we take comfort from the fact that the triumphant bid came from the UK. Or that the kit, consisting of pistols, a brass gunpowder flask, holy water, a Bible, a mallet, a wooden stake, brass candlesticks and rosary beads, also contains some (rather baffling) paperwork from the Metropolitan Police?

Cast adrift

Or how about a gorilla skull? Do look after it, though. On 7 July, YouTuber Nathaniel "Coyote" Peterson, on the hunt for the legendary Sasquatch, conveniently stumbled upon an enormous primate skull in British Columbia. "Leaking pics here before they are taken down and before government/official try to cease our footage," exclaimed his Facebook post, even as the skies darkened under drones piloted by the shiba inus of the deep state. The only snag being, it has been spotted that the skull bears a more than passing resemblance to a replica gorilla skull on sale on AliExpress. That is no way to dispose of an unwanted present.

What could go wrong?

Feedback's attention was also snared by an altogether more humble discovery this week. It seems that some species of parasitic nematode worm are attracted to cancer cells. Now, scientists from Osaka University in Japan are covering the worms – which usually live in marine environments "but can colonize humans when ingested" – with a thin hydrogel sheath that could be loaded with anticancer drugs. As one Reddit observer put it, "they use the worms to kill the cancer. Then they use Chinese needle snakes to eat the worms. Then we found a species of gorilla that subsists entirely on snake meat. And in the winter all the gorillas freeze to death." Seems reasonable to us. ▮

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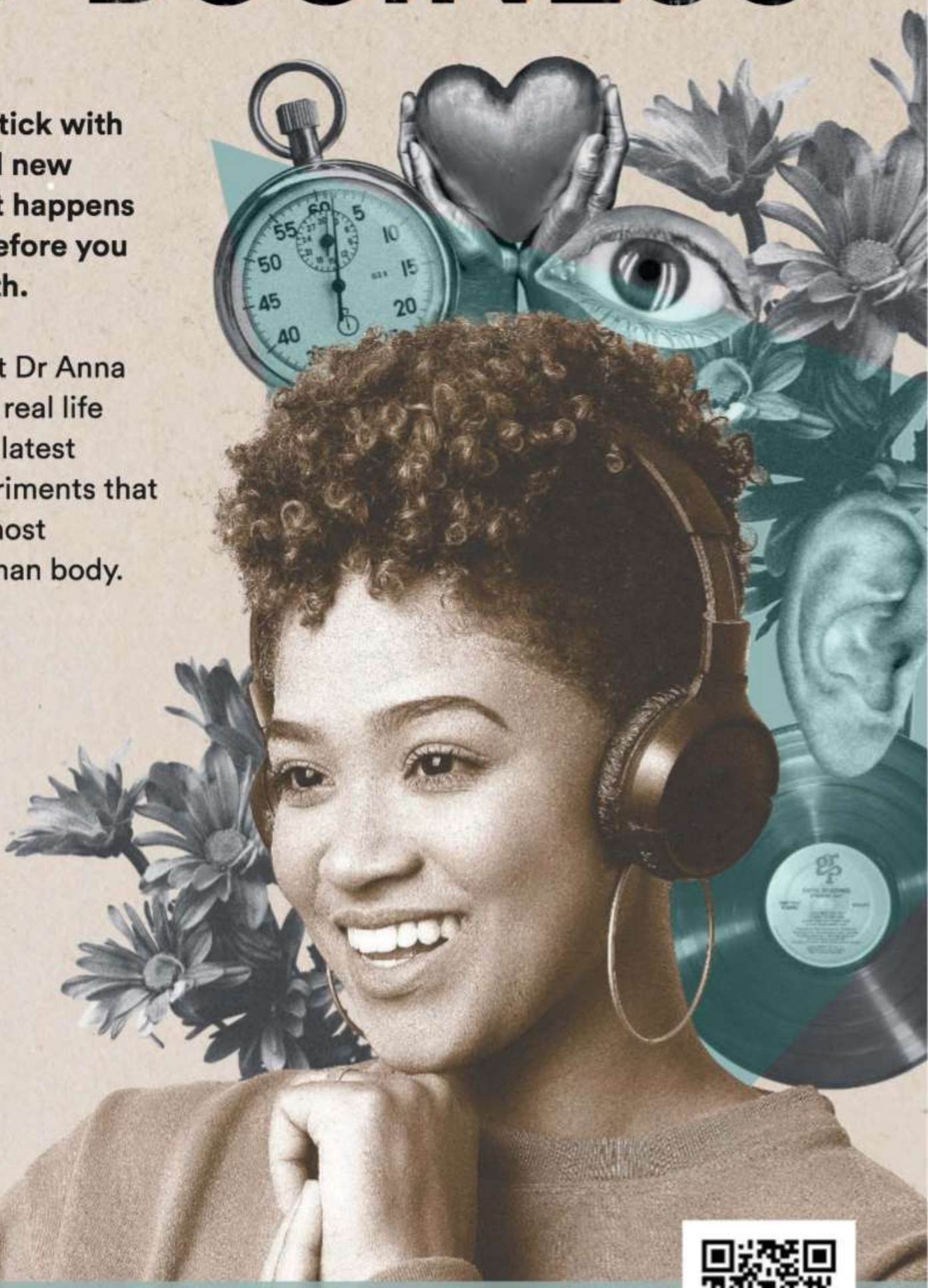

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